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MONDAY—NOVEMBER 11

Chairman—F. G. WALTON SMITH, *Chairman, Gulf and Caribbean Fisheries Institute; Director, The Marine Laboratory, University of Miami, Coral Gables, Florida*

WELCOMING ADDRESS

JAY F. W. PEARSON

President of the University of Miami

I AM HAPPY INDEED that I am privileged to welcome you here to this tenth session of this Institute, which is probably now the best known meeting of its kind, because it brings together both scientists and business men, combining discussions devoted to research, as well as to discussions of the practical application of scientific findings.

We are pleased that various business groups, such as the Shrimp Association, have recognized the importance of basic marine research, by providing funds for graduate fellowships in fishery. Business, thus, is working hand in hand with men of science in furthering our knowledge of the sea.

Many of you have come here from other cities and states and from foreign countries, and I wish to assure you that we appreciate deeply your willingness to travel far to participate in this conference. I am delighted to greet the Honorable R. A. Gray, Secretary of State of our Great State of Florida, who is representing Governor Collins. Mr. Arnie Suomela, Commissioner of the United States Fish and Wildlife Service, has honored us by traveling here from Washington. Mr. John Ferguson, President of the Southeastern Fisheries Association and the Shrimp Association of the Americas, is also with us. I congratulate you, Mr. Ferguson, on the farsighted policy of the Shrimp Association in supporting the fellowship program that I mentioned previously.

In all, there will be some 250 people in attendance at this conference, people from the Caribbean and other countries. Truly, it is of international scope and significance.

The University of Miami is happy to serve as the catalyst in bringing you together for this meeting of minds. We recognize that a meeting such as this is vital to the public interest. All of you are bound together by your common interest in the sea, that remarkable mass of water that covers so much of our globe and plays such an incredible role, an ever-growing role, in our civilization.

We think of the sea as the place where life originated on this planet. We recognize the fact that life could not exist if the sea did not exist. Mankind has studied the sea and used it steadily, but knows only a fraction of its mysteries, and has utilized it to only a fraction of its total potential of service to humanity.

The University of Miami has always been interested in the sea, particularly in the warm water that surrounds our peninsula of Florida and bathes the shores of our sister nations of the Caribbean and Gulf of Mexico, though it recognizes no spatial limitation to the breadth or depth of its interest in this

restless and fascinating ecological area. Under the able direction of Dr. F. G. Walton Smith and his associates, we have been able to make major contributions to Man's relatively small body of marine knowledge.

As our University grows in resources, we look forward to an ever-broadening activity in this field of study and teaching. Our University is young; our Marine Laboratory is young. But we take pride in our past accomplishments and welcome every opportunity to cooperate in the vast and challenging effort to learn more about the natural laws governing the sea and its flora and fauna. Man's future may well depend on knowledge growing out of this research and out of conferences, such as this one, which you are attending.

I sincerely hope that this tenth conference will be highly productive and will be stimulating to each of you. May it prove of real benefit to mankind.

OPENING ADDRESS

A Glance at the Past — a Look to the Future

ARNIE J. SUOMELA

Commissioner, U. S. Fish and Wildlife Service
Washington, D. C.

TEN YEARS! 3,653 DAYS! That's a long while, any way you look at it, but it's the amount of time it would take to reverse the clock back to the day of the first meeting of the Gulf and Caribbean Fisheries Institute. As we meet today on this anniversary occasion, it is hard to realize that 10 years have passed so rapidly.

I well remember when the announcement of that first meeting of the Institute was circulated in 1948. I was then responsible for the State of Oregon's commercial fisheries. The announcement of the opening of the Gulf and Caribbean Fisheries Institute to be held in a far corner of the United States looked like the start of just another fisheries meeting. However, it was refreshing to find Dr. F. G. Walton Smith, the prime mover in this new organization, being credited with the following statement in the opening session address, "Many of us are beset by increasing demands upon our time in the form of meetings or conferences, international, national, state or local in scope. The Institute which begins its inaugural session today is only justified, therefore, to the extent that it fills a hitherto unsatisfied demand and to the extent that it does not duplicate the functions of other organizations. The question of whether this should become an annual event will rest largely upon the results of our discussions during the next few days."

The fact that we are here again today, 10 years later, is vivid testimony as to the value of the results of those discussions. It certainly is a pleasure for me to extend a tribute to the members of the staff of the Institute, who in only a decade have made this yearly meeting a recognized forum for exchange of fisheries knowledge and new ideas. Scientists, industry members and public observers who annually gather here from many parts of the United States, and from several other countries, have done much in this decade to pinpoint the Gulf and Caribbean fisheries problems and to focus research in the direction of

their solutions. Indeed, the Institute has matured in an eventful period for the Gulf and Caribbean fisheries.

During these ten years, there have been spectacular developments. It seems appropriate at this 10-year milestone to take count of this progress. Immediately one fact is impressive. The commercial fisheries here have been growing at a more rapid rate than in any other place along our shores. To get some idea of the significance of this, let's look at the statistics. Last year the total landings of fish and shellfish in the Gulf States approached the billion pound mark—specifically 841,000,000 pounds. Ten years ago this production was recorded as a little less than 400,000,000 pounds, not even half of what it is today.

As startling as this increase may be in total magnitude, equally spectacular things have been happening in individual fisheries in the Gulf. The shrimp fishery has moved into first place nationally on the basis of value of the catch. In providing an income of between $60,000,000 and $70,000,000 annually to Gulf fishermen, it yields a greater value than any other single fishery in the United States.

On the other hand, the menhaden fishery, a considerable part of which is conducted in this area, is the number one fishery in the United States, based on volume of production. Ten years ago the big expansion in this fishery on the Gulf Coast was just starting. From that time until today it has expanded to the point where it now supports a large fleet of vessels and many more shore plants for processing fish meal and oil products.

There are many other fisheries, among them oyster, red snapper, mullet and blue crab, which produce lesser quantities commercially, but which nevertheless are an important part of the Gulf fisheries. Beyond this, there are some new developments in this area which we might refer to as still in the embryonic stage, but which conceivably can have a substantial potential. These involve commercial utilization of the tuna and deep-water shrimp resources.

I might say right here that all of this has been a healthy expansion of the industry. Most of the Gulf products are the type that find a ready demand in the market. In many cases, even greater production would be welcome because markets for such products as shrimp, oysters and red snapper are active and not stagnated by lack of demand, as is the lamentable situation in some fisheries in other areas.

It was inevitable, however, that such rapid development and growth would be accompanied by many problems which beset both the industry and the conservation agencies concerned with them. These problems center mainly around the source, quantity, quality and timing of the supply. Fish need to be delivered in the right amount and in such a way that shore operations can proceed smoothly and that consumers can be satisfied. Quality as well as quantity counts. This means receipt of marketable sizes of fish and shellfish enhanced by such attributes as freshness, good flavor and appearance. More important than any other need in the industry is the establishment of a steady supply of this kind of raw product. Periods of glut and scarcity are headaches in this business.

There have been many good production years in the Gulf industry, but we know that it is impossible to have such a rapid expansion of production in a body of water, even as large as the Gulf of Mexico and the Caribbean, without exerting increasing fishing pressures on the stocks of fish existing there. Because of this increasing strain on these fish and shellfish populations, there is all the

more reason to apply the best management techniques to them in both the open waters and in the estuarine water areas which form the nursery grounds for most of the commercially important Gulf species.

Probably the most vital problem in this connection results from the conflicting interest in use of estuarine waters in coastal marshes and bay areas for fishing, navigational channels, flood control projects and oil production facilities. Certainly it is not necessary to explain further to the people assembled here today the great importance of these areas in maintenance of Gulf of Mexico fish and shellfish populations. We cannot stress too much, however, how important it is to be constantly alert and ready to act to protect and preserve these areas. That means the industry, state conservation agencies and the Fish and Wildlife Service must act with the utmost cooperation in meeting threats of physical changes being brought about in these areas without regard to the future welfare of the fishery resources.

This subject has been fully discussed at recent meetings of the Atlantic and Gulf States Marine Fisheries Commissions. We are all becoming increasingly aware of the vital need to find out more accurately through research just what will take place in the coastal and estuarine fish producing grounds as a result of various water use projects—these being planned and in some instances those already being implemented.

There are other problems which have arisen and for which we have no immediate answer in assuring future supplies of fish and shellfish. As an example, we are unable at present to explain why there have been such severe fluctuations in relative amounts of brown and white shrimp taken in the Gulf of Mexico. This phenomenon should be understood so that fishing can be managed on a scientific basis and changes in available supplies anticipated with attendant benefits to fishermen, processors, and marketers.

Plainly speaking, we require knowledge about a great variety of factors which combine to control production of fish and shellfish in the Gulf. We must seek that knowledge.

Concurrently with good management of the established and more mature fisheries, there is the need to search into the deeper and more distant waters of the Gulf and Caribbean to detect additional fishery resources. Exploration of offshore fishing grounds has been quite successful in pointing the way to new tuna and shrimp resources in the Gulf. This work in itself has raised some problems of a different nature. These generally relate to the development of gear and methods of fishing suited to conditions in deep water where weather, currents and other factors demand vessels with more power, heavier deck equipment and somewhat different design of fishing gear than most shrimp vessels now possess. These are temporary problems, but still complex enough to require considerable research and engineering efforts.

The development of the menhaden fishery on a broad scale in the Gulf has generated some technological problems stemming from increased rates of spoilage of fish which take place because of the high air temperatures in this region. This problem has been solved to some extent by efforts of the industry and Government researchers. The most promising solution, the use of refrigerated "chill" tanks aboard the vessels, is now in use in nine Gulf menhaden seiners. There has also been increasing pressure for improvement in the quality of fish meals and oils. Technological studies by the Bureau of Commercial Fisheries and contract research by other organizations on possible new uses

for fish oils and development of a rapid means of measuring the nutritive value of the meals are frontal attacks on these problems.

In the canning industry, certain technical problems always seem to be springing up. Our new Pascagoula laboratory will be especially helpful here. In connection with the production of fresh and frozen products, perhaps our greatest problem is maintenance of uniform quality and establishment of good, sound voluntary standards for them. There is progress being made in this field, but more needs to be done.

I have said that Gulf and Caribbean marketing problems were much less formidable than those in many other fishing areas. While this is true in general, there are some individual marketing situations for southern species that have caused real anxiety. A good example is the mullet, which is the bread and butter producer in many southern sections. Mullet has been a victim of changing consumer preferences. This has resulted from new buying patterns, development of more conveniently prepared foods, and the invasion of the historical mullet market by highly competitive products from other parts of this country and even from other countries. Development of a canned mullet product and packaging of the dressed fresh fish in cryovac containers is giving rise to signs that the mullet fishery may be working itself out of this marketing predicament.

In an entirely different category is the challenge of marketing the new Royal Red shrimp as they come into commercial production. People who have tried these shrimp agree on their delicious texture and flavor. Nevertheless, consumers still buy with their eyes. The natural bright red color of these shrimp raises a danger signal in the eyes of many consumers who associate that color with spoilage. This is not a new problem. Actually, it is almost a matter of history repeating itself. An identical situation arose several years ago when the first pink shrimp were placed on the market. It was resolved through consumer education. The red shrimp marketing problem can be handled the same way, but somebody has to do it.

Every one of these situations I have mentioned is going to require time and money to master. Some of them are short term problems; others are more deeply rooted and long range. Whatever their nature, I do know one thing for certain. It will take the combined efforts of industry, State and Federal agencies and public institutions, working in complete harmony, to attack them effectively.

In the hope of achieving closer association with those people and the organizations most directly concerned with the fisheries in each area, the Bureau of Commercial Fisheries in the U. S. Fish and Wildlife Service is establishing Regional offices. Program directors from these new offices will strike at the very heart of the kind of problem I have just discussed. I am pleased to say that one of the Regional offices is concerned exclusively with the South Atlantic and Gulf area. Located at St. Petersburg, Florida, it will coordinate all of the activities of the Bureau, bringing them together in sharp focus on commercial fisheries problems as they arise. In this way it is our feeling that our programs can most effectively be made to serve both the States and the industry. They will be dedicated to those objectives.

MONDAY—NOVEMBER 11

Chairman—F. G. Walton Smith, *Chairman, Gulf and Caribbean Fisheries Institute; Director, The Marine Laboratory, University of Miami, Coral Gables, Florida*

Progress in Fisheries Technology in the Gulf and Caribbean Area, 1948-1957

Lawrence William Strasburger

Food Technologist and Consultant
Metairie, Louisiana

Today, the Gulf and Caribbean Fisheries Institute celebrates its tenth anniversary. What advances have been made in the fisheries technology during the decade of our existence?

Webster's dictionary defines technology as "that branch of knowledge which deals with the various industrial arts." So we may define fisheries technology as "that branch of knowledge which deals with fishing, the fishery, and the preparation of articles of commerce therefrom."

Thinking back over the last ten years, we can see some results of applied technology, and it is only with these concrete advances that I shall deal. While I shall review only techniques which have wrought changes for the betterment of the industry, there has been much progress in a number of directions on which I shall not touch in the present review.

Let us first take a look at the actual fishing industry itself. The greatest tonnage comes from menhaden, so we will begin with this fishery. Its use of the purse seine power block, which eliminates considerable manpower in the pursing and handling of the net, is an important advance. The use of shipboard refrigeration also allows the menhaden fishermen to make longer trips to obtain a pay-load, and brings in the fish in a firm state. This gives a higher yield to the fishermen and a higher protein meal to the processing plant.

For the commercial red snapper fishermen has come the elimination of the backbreaking job of hand lining, through the perfection and adoption of both mechanical and electrical reels.

With the discovery that longlining for tuna could be commercially successful, the prospects for a new cash crop in the Gulf have materially brightened, not only for the fishermen but for the shore workers as well. While speaking of cash crops, the new trash-fish industry, which is producing thousands of cases of cat food a year, has given added revenue to our fishermen through applied technology.

New tools have been placed in the hands of the men engaged in fisheries research. Underwater television has been utilized to watch the operation of trawl nets in action, while actually catching shrimp and fish. Underwater cameras give a permanent record on film of what happens during fishing operations. The telemeter accurately shows the depth at which nets are working. New types of tags and methods of marking, such as darts, spaghetti tags, and

dyes, have been developed so that migrations may be checked and life cycles better worked out. Sonar is being used to locate shell reefs.

Practically unknown on the shrimp boats of 1948, today the fathometer is a "must" for all offshore fishing. Other electronic devices now in use, which might be mentioned as aids to the boats, are radar, direction finders, Ioran and autopilots. Webbing, nets and ropes have undergone a change. Synthetic fibers, such as nylon, dacron, and polyethylene, with their abrasive resistant and rot resistant qualities, are coming more and more into use. "Mud ropes" have been utilized in the Delta area of the Gulf, so that the boats may trawl without bogging their nets in the mud lumps.

These and other technological advances have assisted the Fish and Wildlife Service in their deep water exploratory fishing, which resulted, among other things, in the finding of commercial quantities of Royal Red Shrimp.

A tremendous advance in the production of good quality frozen headless shrimp has been made by the utilization of immersion freezing in brine on board the boats. This freezing system, employing a salt brine-sugar solution as a freezing medium, individually freezes and glazes the shrimp within fifteen minutes, prevents drip losses and spoilage after the shrimp are headed, and places prime fresh shrimp on the market. The use of freezers on the boats allows the vessels to stay out until a pay-load has been fished, thus cutting down costs of production.

Reports so far have indicated that fishing with dual nets, one from each side of the boat, has resulted in higher catches of shrimp than fishing from the stern of the boat with a single net, even when it is larger than the combined sizes of the dual nets.

Technological advances through the use of chemicals and antibiotics have been slow. Although known to have value in extending the "fresh life" of fish and shellfish, the U. S. Food & Drug Administration has not permitted antibiotics to be used on them. Sodium bisulfite, when properly used, has been proven to be an aid in the prevention of black spot in shrimp.

Now let us consider the processing plants ashore. Today's plant has a technological level far above the processing plants of a decade ago. New equipment made possible through technology has eliminated much handling and hand work, resulting in a better product. In the freezing plant we find new elevators and pumps for unloading the shrimp boats, mechanical graders which will sort the shrimp into as many as seven different sizes, new and improved equipment which will not only devein the shrimp, but peel and butterfly them as well, and machinery for individually freezing shrimp.

In the canneries, peeling machines have practically eliminated hand labor by giving consistently higher yields, a steady flow, and by reducing personnel problems. Deveiners which will handle any size shrimp have been a boon to the production and marketing of canned deveined shrimp. Mechanical blanchers, in which the vital point of timing can be completely controlled, are gradually replacing hand operated blanchers. Water cooling of blanched meats, instead of air cooling, has increased yields by stabilizing temperatures and preventing dehydration. This has resulted in the "cutout" weights being more consistent, and in a better flavored product. New type conveyors and food pumps have been installed to smooth the flow of materials and reduce operating costs. Black light has been used to facilitate the detection of adhering shell and shell particles, not only in shrimp, but in crabmeat as well.

A sequestering agent, EDTA (ethylenediamine tetrasodium calciumacetate) in combination with aluminum sulphate, has been tested and proven to be a preventative of iron, iron sulphide, and copper discoloration of canned shrimp. Struvite formation can be completely controlled by its use. The commercial use of EDTA, however, has not yet been approved by the U. S. Food and Drug Administration.

In the crabmeat plants, a mechanical picking machine has just made its appearance. This machine increases yields and successfully lowers costs. Phosphate buffers used in conjunction with the citric acid method for preventing blueing in canned crabmeat, have improved taste and color in the product.

In the oyster canneries, the noise of shells hitting steel pipes in a rotating drum or reel, denotes a technological advance. In January, 1956, the first mechanical oyster shucker in the Gulf area was placed in commercial use. It has completely supplanted hand shucking of steam opened oysters in a number of plants, and is used as an adjunct to hand shucking in others.

Automatic breading machinery and cooking equipment has been quick to materialize in the breaded shrimp and fishstick industries.

New containers, new types of packaging and packaging materials have all had their impact on the industry.

Technology has given rise to a number of newly prepared products: frozen, raw, peeled and deveined shrimp, breaded shrimp, shrimp sticks, shrimpburgers, precooked packaged cocktails, pasteurized shrimp, wagerized shrimp, pasteurized crabmeat, oyster stews and soups, fishsticks, cat food, to name a few. Technologists have also worked out delicious new ways of preparing and serving the crop from the sea.

All in all, I feel that we may take pride in the progress of fisheries technology in the Gulf and Caribbean area in the period 1948-1957.

Progress in Fishery Economics in the Gulf and Caribbean Area, 1948-1957

Richard A. Kahn

The Marine Laboratory
University of Miami, Miami, Florida

The Gulf and Caribbean Fisheries Institute was founded to give members of the fishery trade and scientists the opportunity to discuss problems affecting their specific area. In the first four years of its existence the Institute included the consideration of cost of production and labor problems. Later, emphasis was given to international trade, the specific problems of the spiny lobster and shrimp industries, and questions of general stabilization of the industry, including insurance and loan problems. With the cessation of effective union representation in the Gulf and Caribbean area, discussion of labor problems ceased. Many of the discussions held during the Institute, especially those on loans and insurance, gave impetus to either legislative solutions or to further research.

Let us see in more detail what has happened to the commercial fishery industry in our area during the last ten years. In the period 1948 to 1955 (1955

is the latest year for which we have available complete records) the number of fishermen in the South Atlantic and Gulf States increased from about 33,900 to about 38,700, or 14 per cent, and the number of vessels from 2,500 to 4,145, or about 66 per cent. The South Atlantic and Gulf States did better in this respect than the United States as a whole, where the number of fishermen declined by 8.6 per cent and the number of vessels increased only by 22.5 per cent.

We know from a specific study of the shrimp fleet that not only did the number of vessels increase, but the tonnage also increased. This was caused by the discovery of new shrimp grounds, for example, those near Tortugas, and by the necessity of making longer trips from United States shores to areas as far distant as the Campeche banks. It is mainly due to this development that catches in the South Atlantic and Gulf States increased to high levels. The total catch of all fish and shellfish increased from 1948 to 1955 by 41.4 per cent, as compared with a total increase in the United States of five per cent. Mainly due to higher shrimp prices, the total value of the catch in the South Atlantic and Gulf areas increased by 51.3 per cent, as compared with a decrease of three per cent in the United States catch.

While the gross income from the catch per fisherman in the South Atlantic and Gulf areas was $1,800 in 1948, it was $2,400 in 1955. The gross income per vessel in 1948 was $25,000 while in 1955 it was about $22,000. This decline was caused by the tremendous increase of the fleet. Although the profits of the individual fishing enterprise, taken on a per vessel basis, decreased, the profits per fisherman increased. The catch per fisherman in the South Atlantic and Gulf States was about 24,000 pounds in 1948 and about 30,000 pounds in 1955. In the United States as a whole, fishermen caught an average of 29,000 pounds in 1948 and in 1955, about 33,000 pounds. These figures are highly influenced by the catches of "industrial fishes," mainly menhaden, which give a somewhat biased picture for the person who is interested principally in food fishes. The increase in the catch of industrial fishes in 1955 compared with 1948 was 58 per cent in the South Atlantic and Gulf States, while the increase in food fishes was 21.8 per cent. However, the increase in the value of food fishes was 52.6 per cent, while the increase in value of industrial fishes was only 41.7 per cent.

Landings in the countries of the Gulf and Caribbean area outside the United States from 1948 to 1955 increased about 13 per cent. While this overall increase in the catch did not keep pace with the population increases, which averaged 24 per cent, some specific increases of the catch were phenomenal. For example, in Surinam catches increased 400 per cent from 1947 to 1955, while the population increased only about seven per cent. The Republic of Honduras had a 2500 per cent increase in catch compared with a population increase of 30 per cent in the same period. In Puerto Rico the population increase was 4.7 per cent from 1947 to 1951 while the increase of the fish catch was 66.7 per cent, a surplus of food gains on a per capita basis.

The increase of the population in Barbados was 16 per cent, in Jamaica 18 per cent, in Trinidad 27 per cent and in the Windward Islands 21 per cent. Despite higher population figures, the per capita income in most of the countries in the area increased and this factor had a great effect on the fishery trade. The per capita income in the United States, based on current prices, increased from $1,173 in 1947 to $1,664 in 1956, (42 per cent) or in terms of constant prices, from $1,173 to $1,419. The per capita income on current prices in many states

of the Gulf and Caribbean area increased even more. This increase in Puerto Rico was 55.5 per cent from 1947 to 1955; in Honduras, 55.1 per cent from 1947 to 1956. In Colombia the increase from 1947 to 1954 was 132.8 per cent, and deducting a 30 per cent devaluation of the Colombia peso, it still was an increase of about 95 per cent. Mexico showed an increase of the per capita income of 128 per cent from 1947 to 1955, which adjusted for devaluation of the Mexican peso is an increase of 56 per cent.

In all countries of the Gulf and Caribbean area international trade increased. The value of the United States imports increased 155.5 per cent from 1947 to 1956, while the imports of edible fishery products increased 179 per cent in value, and inedible fishery products, 80 per cent. The value of exports decreased 25.2 per cent (edible products, 53.5 per cent). The decrease of 25.2 per cent was caused by a tremendous increase of exports of industrial products.

Spiny lobsters imports increased from 7,757,000 pounds in 1948 to 25,258,-000 pounds in 1956. About eight million pounds came from the Gulf and Caribbean area, about seven million pounds from South Africa, and about five million pounds from Australia. Shrimp imports increased from 13,275,000 pounds in 1947 to 21,563,000 in 1948 and 68,619,000 pounds in 1956. These shrimp imports came mainly from Mexico.

The volume of international trade in the Caribbean area outside the United States increased by an estimated 63 per cent during the period 1947 to 1955, compared to 82 per cent for the United States for the same period. Exports increased about 84 per cent. Panama had the greatest percentage increase — from 293,000 pounds in 1947 to 4,228,000 pounds in 1955, or 1,343 per cent —while Mexico and Cuba also exhibited large increases. With incomplete data on hand, increases of exports can also be reported for the Bahamas, British Honduras, Honduras, the British Virgin Islands and Surinam. The only country with a decrease of exports was Costa Rica.

Imports of fishery products also were generally higher, due partly to the higher standards of living. Imports averaged about 50 per cent greater in 1955 compared with 1947. Trinidad, the Dominican Republic and Haiti played a major part in this percentage increase; smaller increases are observed in Panama and Jamaica. Generally speaking, the import increases were greater than the population increases, being about in the same percentage range as per capita income increases. Only Venezuela is an exception, and here there was no increase in imports, despite a population increase of 30 per cent.

In most countries of the Gulf and Caribbean area outside the United States dried salted fish was the most important import item among fishery products, with canned fish ranking second.

What can be predicted for the next ten years, and what should be the goal of our activities during this period?

We should first consider the increase in population, which will be about one-sixth more in 1967. This means that there will be about 23 million more people in the United States and about 15 million more in the Gulf and Caribbean area outside this country. The rate of increase is about the same in the United States and in Caribbean and Gulf areas outside the United States, but there are differences in the ability of various countries to absorb the additional population. The United States will absorb all its new people, but there will be a greater increase in the population in the South than in the North. The fish production in the South Atlantic and in the Gulf areas will be utilized more in the Southern area of the United States and will be less available for general

consumption and export.* Studies should be made on how the shift of the population will affect the fishery industry.

Not only has the fact of increased population to be considered, but also the changing of population composition by age groups. This may change the demands for certain particular types of fish and the fishery trade will have to become more selective. Our studies should extend to the economics of diversification in production and manufacturing. The composition of the United States population by age classes in 1940, and projected to 1975, may be seen from the following graph.

COMPOSITION OF UNITED STATES POPULATION BY AGE CLASSES, 1940 and 1975

Projection AA

Percentage in each five-year age class

Source: United States Bureau of the Census.

Percentage in each five-year age class

** Series AA estimate assumes that 1954-55 birth rates will continue to 1975.

Source: Projection by Meyer Zitter, United States Bureau of Census.

The increased population will need more food. This will not necessarily mean fish food, but the population will eat nourishing and relatively cheap food. Food prices in the United States are expected to increase generally because much land formerly used for agricultural production is abandoned, because there will be greater income opportunities in industrial manufacturing and because Europe will need more and better food and will be better able to pay for it. Whether fish food consumption increases greatly depends on the interrelations between prices of fish and prices of agricultural products. The Caribbean population, for many years to come, will need dried salted fish, and imports of this product and canned fishery products will increase in common with all imports.

North America depends for its fish to a large extent on imports. If European countries increase their prices and demand for fish, these products may become short in supply. For example, France and Italy pay higher prices for tuna than

*LCL express shipments of fishery products from New Orleans to South Atlantic States have been three per cent in 1954, five per cent in 1955, seven per cent in 1956, and ten per cent in July, 1957.

the United States does and fish exports from Europe to the United States may be seriously reduced. The fishery resources of the United States may not be rich enough to replace diminishing imports from Europe. Our studies must extend to research on resource development and its economic basis.

It may be that fresh water pond fish production can supplement fish production from the sea. There are already more than a million fish ponds in the United States and pond fish production has made good progress in some Caribbean countries, for example, Haiti. While the production from these ponds is not great at present, it may increase and eventually become a great source of food. Studies should, then, consider the economic importance of pond fish production.

Forecasts for the United States indicate that there will be a reduction of the working hours per week to about 38 by 1967, which leaves more time for leisure. There may, as a consequence, be more fish caught by sport fishermen with a resulting decrease in demand for commercially produced fish. We should keep a watchful eye on the fish production by anglers and sportsmen, and evaluate its economic importance.

I do not share the view of some economists that this country will continue to increase its production level at a high rate. Some economists believe that each individual in the United States will spend $1,970 on consumer expenditures in 1965 as compared with $1,530 in 1955. I consider this possible only under conditions of a continued inflation of about three per cent per year. If the Federal Reserve Board continues its present policy of stemming inflation, neither a 30 per cent inflation nor a 28 per cent increase in consumer expenditures will occur during the next ten years. Inflation increases the prices fishermen have to pay for their goods more than it does the price of fish landed. The value of food fishes increased only 6.9 per cent in the last ten years on a volume basis. With continued inflation the commercial fisherman will be the loser. Our Institute must continuously study the monetary values, consumer spending, fish prices and their interrelations.

Assuming a stable economy all over the world for the next ten years, population increases and the changing demand will be of a great challenge to fish producers, processors and dealers in the Gulf and Caribbean area. The greatest challenges will be in how to produce more fish and how to provide diversification of fishery products as required by the changing composition of the population. It is to be hoped that the tremendous development in the shrimp industry in the Gulf and Caribbean area will continue and that other fish industries, for example, the tuna industry in the Gulf, will experience similar growth. The Gulf and Caribbean Fisheries Institute, by its discussions of the economic problems, will hope to contribute even further to the improvement of the fishery industry in the future than it has in the past.

Progress in Fisheries Education in the Gulf and Caribbean Area, 1948 - 1957

C. P. Idyll

Chairman, Department of Marine Sciences
University of Miami

Everyone having any connection with fisheries, whether from the industrial or professional point of view, has been made repeatedly conscious of the severe

shortage of technically trained fishery scientists. Directors of fishery research programs spend a considerable part of their time searching for men to carry out the increasingly complex tasks that are posed to the science of fisheries. Despite this energy, which should be available for more productive activities, many fishery staffs are forced to include people only partly trained or actually untrained in fisheries or its related disciplines. The new information, which has been accumulating at accelerating rate in recent years, makes it the more necessary for the universities to turn out trained technical scientists.

In addition, the fisheries of the Gulf and Caribbean area have had a considerable growth in recent years. This adds local urgency to the country-wide problem and makes it especially worthwhile to examine, on the occasion of our tenth meeting, the progress made in fishery education in this area and in the period of the existence of the Gulf and Caribbean Fisheries Institute.

This progress has been good. Before we can defend this statement properly, however, we will have to decide what to include when we speak of "fisheries education." Perhaps the simplest and most useful definition is that fishery education is training that prepares a man with the knowledge and skills necessary to solve fishery problems. This means that a good training in zoology (or sometimes chemistry or one of the other sciences) can lead a man to a useful career in fisheries science. However, as fisheries develops its own techniques, there is an increasing need for training in these special procedures. Certainly some of the most useful work in this field will continue to be done by men who have never taken a "fisheries" course, but it seems certain that the great advances in the science—the "break-through" progress which will lead to new plateaus of understanding—will be achieved to an increasing degree by men who have studied the specialized aspects of fish population work and the newer techniques which are beyond the purview of classical zoology.

Thus, in considering fishery education programs in the Gulf and Caribbean area, we will limit it to courses of training in marine biology, oceanography and fisheries, which can lead to a solution of marine fisheries problems. (We omit, for our present purpose, freshwater fishery training.)

Fishery education can be divided into a number of categories: (1) the training of fishermen in new techniques and procedures, (2) fishery education in the secondary schools, (3) professional education at the university level in fisheries and other marine sciences.

Vocational education for fishermen and secondary school education have only begun to be started on a small scale in the last two years in our region. We are on the verge of considerable activity in this type of work, if present indications are reliable. A bill, sponsored by Senator Frederick Payne of Maine, and put into effect by the last Congress, is largely responsible for this, and several states, notably Louisiana and Texas, have already begun to organize training to improve the efficiency of fishing operations and to attract new recruits to the trade.

In Florida our own University, with the help of the Florida State Board of Conservation, organized and assisted in the conduct of a fisheries club among high school students in Ft. Myers. We had hoped that this would be the prototype of a number of similar clubs, which would encourage boys to enter either the trade of fishing or the field of professional marine science. Whether this hope will be realized remains to be seen.

Fishery education in the Caribbean area has been supported by the Food and Agriculture Organization, which sponsored two short schools in fishery

biology (Valparaiso, Chile in 1952, and Mexico City, 1954), and in 1957 conducted a course in fishery technology in Lima, Peru. These courses, of about two months duration, draw men from many Latin American countries and present to them the elements of fishery science. This activity should have good results, and may be the spark to alight productive interest in professional fishery activities in this area where little such research has been conducted.

Professional training in fisheries and other marine sciences in the universities is at two levels in our area. First, there are universities and especially marine stations, which offer summer courses in these subjects, or which offer some specialized courses in the marine sciences during their regular session, but which do not grant degrees in this specialty. This group includes such institutions as the College of William and Mary, the University of Georgia, Louisiana State University, the University of Texas, University of Florida, Duke University and Florida State University.

The Virginia Fisheries Laboratory is affiliated with the College of William and Mary, and offers some academic training in fisheries. Dr. J. L. McHugh, Director of the Laboratory, state ". . . our graduate program . . . is much less formal than the usual program on a college campus. . . . we do not offer any formal courses, but try to broaden the students' training by offering courses under the category 'Problems in Biology' in as wide a variety of subjects as our staff members are qualified to teach . . ."

Tulane gives graduate courses in ichthyology and fishery biology, in alternate years. The University of Georgia offers a two-quarter course entitled Marine Biology, which embraces principles of oceanography with emphasis on biology, and a course in ichthyology. Louisiana State University supports a faculty member at the Gulf State Research Laboratory at Ocean Springs, Mississippi, during the summer, and sponsors summer courses there in Marine Zoology, Marine Biology for Teachers and Problems in Marine Biology.

The University of Texas has offered summer courses in Marine Fisheries Biology, Marine Vertebrate Zoology, Marine Invertebrate Zoology and Biological Oceanography when demands justify it. This program is being broadened to include geology, botany and bacteriology. Florida lists one marine course (Marine Ecology). At the University of North Carolina zoology students may take several courses in marine subjects and pursue research at the affiliated Institute of Fisheries Research at Morehead City, North Carolina.

At Duke University courses such as Marine Ecology, Marine Invertebrate Zoology and Marine Algae are offered, among others. Duke also gives summer courses at its Marine Laboratory at Beaufort, N. C. Support is given to these by the nearby Fisheries Laboratory of the Fish and Wildlife Service, whose staff also attends courses in such topics as fish population dynamics and biometrics.

Among the institutions in this first group, Florida State University offers the largest number of courses in fisheries and cognate subjects. These courses, which include such specialized subjects as Marine Bacteriology, Gulf Coast Ecology, Elementary Physical Oceanography, Plankton and Biology of Fishes, are offered by the various science departments. Many of the courses helpful in training a marine fishery scientist are at the graduate level, and a student can get an advanced degree in Bacteriology, Botany, Geology, Meteorology or Zoology with at least some marine courses if not a strong specialization in problems of the sea.

The second group institutions in the area are those which offer a specially

designed marine science curriculum and grant degrees in Oceanography, Fisheries or Marine Biology. These include Texas A & M College and the University of Miami.

Texas A & M established a Department of Oceanography in 1950. Students are offered the choice of five areas of specialization at the graduate level and may also take an undergraduate curriculum in meteorology. The graduate options are Physical Oceanography, Biological Oceanography, Meteorological Oceanography, Chemical Oceanography and Geological Oceanography. More emphasis is placed at this school on the physical science aspects of ocean study than on the biological, as evidenced by the fact that six out of the seven Ph.D. degrees granted up to January, 1957, were in geological, physical, chemical or meteorological oceanography, and 26 of the 28 masters degrees were in these categories.

At the University of Miami fisheries and allied courses are taught in the Department of Marine Sciences. This department was established as a separate academic unit in 1949, with the realization that the study of the sea encompassed all the sciences, and that specialized consideration of marine problems required a special approach. No undergraduate degree is offered in Marine Sciences, students being accepted to a graduate program after having obtained a sound training in one or more of the sciences. Three options are available for students seeking the M.S. degree, these being Marine Biology, Oceanography and Fisheries.

Marine Science courses are taught by senior staff members doing research in The Marine Laboratory and an important part of the student's training is his internship as an assistant on research projects. Marine courses include Marine Biology, Marine and Freshwater Plankton, Physiology of Marine Organisms, Chemical Oceanography, Marine Geology, Fishery Biology and Management and a considerable number of other specialized courses.

A few of the courses in some of the universities mentioned above were in existence in 1948, when the Gulf and Caribbean Fisheries Institute was founded, but the number was small and most of them were of the classical zoology type. In a paper entitled, "Education and Training for Oceanographers," published in 1950 (Knudsen et al., 1950), no institutions in the Southeast or Gulf and Caribbean areas were listed among the "well established oceanographic laboratories." Among schools in this area only Texas A & M and the University of Miami are listed as offering "courses in oceanography" or "conducting research involving oceanography," and these were mentioned almost in passing. Thus, virtually all the specialized training in marine work which could be called "fisheries education" has been started since the Institute began in 1948. It may therefore be said with confidence that very considerable progress has been made in this field in the years under consideration.

What can we expect in the next ten years? I have no doubt at all that the present strong demand for trained fishery scientists will increase steadily in the next decade. Demand stimulates supply and more opportunities for training in this field are certain to be offered. Dr. Dale Leipper, Head of the Department of Oceanography at Texas A & M, writes, "We are beginning a new period of emphasis on the applications of oceanography to fishery problems. . . . our emphasis will continue to be upon the environment as it affects the fisheries." At our own institution we feel that we are also on the verge of a period of fruitful expansion. Beginning in September, 1958, we will accept applications for ad-

mission to a Ph.D. program in Fisheries, Marine Biology and Oceanography. This program will start in 1959.

An educational program has one basic and necessary ingredient—students. A good faculty and well equipped library and laboratory facilities are of little use if students cannot be induced to use them. The shortage of scientists of all kinds is too familiar a complaint to dwell long upon here, but it can be said with much truth that the shortage is more severe in fisheries and other marine sciences than in most other areas. The reason for this is a compound of salaries, which are lower than those for men of comparable training, and a general unfamiliarity on the part of students with the very existence, let alone the satisfactions, of fisheries science as a career. The situation is being improved by an increasing salary scale, wider information about the profession and increasing financial aid for fisheries students. It is significant that industry recognizes the problem of attracting able men to the marine science profession, and Texas A & M lists three industrial fellowships. Of particular interest to the fishing industry of this area are the Shrimp Association of the Americas Graduate Fellowships, which were set up at the University of Miami this year by the joint shrimp industries of Mexico, Florida and Texas. This type of foresightedness on the part of industry is bound to have far reaching good effects.

The past decade has shown a substantial increase in the awareness of need for fisheries education in this area, with marine courses being added in many Universities and teaching and research facilities being greatly increased. There is every reason to believe that this trend is gathering strength and we can hope for much greater progress in the decade ahead.

A Decade of Progress in Fishery Biology of the Gulf and Caribbean Area

PAUL S. GALTSOFF

Fish and Wildlife Service
Woods Hole, Mass.

THE OFFICERS of your organization asked me to discuss at your opening session the progress made during the past decade in the studies of biological problems pertaining to the fisheries of the Gulf and Caribbean area. I am very happy to address this meeting today because the Gulf and Caribbean Fisheries Institute, inaugurated in 1948, was a major factor in this progress. In his welcoming speech, Dr. F. G. Walton Smith, the chairman of the inaugural session said: ". . . The Institute . . . seeks to bring together first of all fishermen, the fish dealers, the fish processors; secondly, the fishery biologists, technologists and economists; and thirdly, the conservation administrators of the fisheries. In this manner it is believed that the several groups of persons . . . may have an opportunity of broadening their horizons and of seeing their problems in a truer perspective against the background of fisheries as a whole." Those of us who have followed the growth and activities of the Institute have no doubt that this particular aim, outlined by its originator, has been fulfilled. The Institute has provided the means of understanding and communication between

the specialists and laymen. This contact is frequently lost because of the rapid progress of scientific knowledge, the usage of new terminology, and the peculiarities of scientific thinking which are not always comprehensible to the general public.

The second meeting of the Institute, held here in Miami in 1949, inaugurated a project of summarizing the knowledge regarding the Gulf of Mexico. Thanks to splendid cooperation of many members of the Institute and of affiliated organizations, this project was completed and resulted in the publication in 1954, by the Fish and Wildlife Service, of a book entitled, "Gulf of Mexico, Its Origin, Waters and Marine Life." Information contained in this book makes a convenient stepping stone for making an appraisal of the progress attained during the intervening years.

Let us consider first what conditions are essential for success of any research project and let us determine whether they are present in the Gulf area. Fishery biology is a branch of applied science which combines several disciplines, including oceanography, geology, zoology, botany, mathematical statistics, physiology, ecology, biochemistry and technology. Fishery investigations cannot be conducted in the quietness of a laboratory away from the sea. They require shore installations, adequate floating equipment and trained personnel capable and willing to spend many days at sea. There are now several places along the Gulf coast and in Cuba where facilities for marine research are available. It is true that only some of these institutions have at their disposal funds and vessels large enough to extend scientific operation to a considerable distance from home ports. Others are primarily engaged either in teaching or in research dealing with local problems. Progress of scientific research depends on the availability of well trained scientists, interested in fishery biology as a scientific career. This human material is being provided by several local institutions affiliated with the colleges and universities of the Gulf area. The ever increasing number of students receiving training in The Marine Laboratory of the University of Miami and in other scientific establishments along the Gulf coast, constitutes the cadre of scientists for the expanding research program.

Shore laboratories, adequate floating equipment, and sufficient funds are naturally the prerequisite conditions for the progress of scientific research; they do not constitute, however, a creative force which stimulates scientific thinking and brings about the solution of a scientific problem. Originality of thought among the young scientists should be encouraged at every step of scientific thinking and more time should be devoted to theoretical considerations underlying research problems and to critical definitions of specific research problems. There is always a danger that the neglect in theoretical thinking and in formulation of a research problem may lead to repetitious and wasteful accumulation of observations. High academic standards maintained by principal educational institutions of the Gulf area constitute a guarantee that this is not the case.

It is obvious, of course, that sufficient background information is needed before an attempt is made to outline a more complex analytical study. The last ten years of research yielded abundant results pertaining to living resources of the Gulf. The following are probably the most spectacular results. Exploratory fisheries operations conducted by the Fish and Wildlife Service research vessel *Oregon* by using various types of gear in depth from 10 to 250 fathoms yielded 630 species of fish, of which number 10 species were new. Among the

crustacea two new genera and sixteen new species of decapods and three new species of stomatopods were described and the collection of various mollusks provided interesting facts about their distribution. It is clear from the results of this work that our knowledge of Gulf fauna is incomplete, even with reference to the important species of fish and Cephalopods.

Knowledge of the life history of a commercial species of fish or shellfish constitutes a basis for formulating sound management of the resource. Studies of black mullet, *Mugil cephalus,* in Florida conducted by C. P. Idyll and J. W. Sutton of The Marine Laboratory of the University of Miami, have demonstrated that in each area of the Florida coast the fishery is largely dependent on its own stock, that fishing has a considerable effect on the local population of fish, and that east coast, west coast and northwest coast populations are biologically different from one another and therefore should be treated as distinct groups as far as regulation of fishery is concerned.

The migration of the giant bluefin tuna and related species was the object of studies of the Miami Laboratory, Woods Hole Oceanographic Institution, the Laboratory in Bimini and other organizations. Marked hooks were used for tagging and interesting observations on migration of this fish as they moved north from the Florida Straits to Nova Scotia were made from airplanes. Study of the biology of these fishes is by no means complete, but a better understanding of their movements and spawning habits has been attained.

New data to the life history of the sailfish, *Istiophorus americanus,* in Florida waters, together with the observation on spawning habits and methods of feeding, have been added independently by J. W. Gehringer of the U. S. Fish and Wildlife Service and by Gilbert L. Voss of the Miami Laboratory. The fish was found to be extraordinarily fertile, the gonads yielding from 2.3 to 4.6 million eggs.

With reference to purely estuarine fishery, the seasonal movements and growth of the Atlantic croaker, *Micropogon undulatus,* in Lake Pontchartrain were studied by R. D. Suttkus of the Zoology Department of Tulane University. Although this species contributes only about 600,000 pounds of meat annually or less than one quarter of one per cent of total fish production in the Gulf and eastern Florida, the fishery is quite important for local communities on the shores of Lake Pontchartrain.

Detailed ecological study of the fishes in the vicinity of Cedar Key, Florida, made by George K. Reid of A. & M. College of Texas, added considerably to the knowledge of speciation, biology, movements, and feeding habits of 122 species of local fishes. This type of work is a desirable continuation of ecological studies of Gulf fishes initiated in 1938 by G. Gunter.

Among the many studies of invertebrate populations of the Gulf, mention should be made of the monographic treatment of the taxonomy of *Cephalopoda* by G. L. Voss. This study has increased the list of known species of these mollusks in the Gulf from 26 to 42 and added one new genus and four new species. It is of interest to note that only less than 10 per cent of the species recorded are endemic, the remaining being either circumtropical warm water forms or those of North Atlantic origin. This conclusion is of interest from the point of view of zoogeography, especially if one compares the Gulf Cephalopod fauna with that of the Mediterranean which has been noted for the number of endemic species.

Our knowledge of the distribution and ecology of marine borers of the family *Limnoridae* (*Isopoda*) in North and Central America was much augmented by comprehensive treatment of the subject by R. J. Menzies of the Lamont Geological Observatory. Studies of the biology and physiology of shipworms, *Teredo, Bankia* and *Phyloteredo,* made in The Miami Marine Laboratory provided scientific foundation for the development of control measures. Practical implication of this type of study is self-evident.

It is a well established fact that shrimp populations make regular inshore and offshore migrations and that estuaries along the coast of the Gulf are the nursing grounds where juvenile shrimp feed and grow before setting their course to the open sea. The full importance of the estuarine period of life and the dependence of shrimp on certain types of food is not, however, fully understood. Likewise, further ecological studies are needed to determine the effects of competition of shrimp with noncommercial animals and the effects of biological associations between shrimp and other animals during their estuarine and oceanic periods of life. The work conducted during the past decade was primarily of exploratory nature; successful attempts were made in locating new shrimp grounds and in determining the size of stock available to the fishery. In the course of these investigations a new resource consisting of royal red shrimp, *Hymenopenaeus robustus,* was discovered by the Gulf Fisheries Exploration and Gear Unit of the U. S. Fish and Wildlife Service at Pascagoula. This red shrimp provides a new, tasty variety to the existing shrimp industry. It is worth mentioning here also a theoretical study made by James B. Higman of the University of Miami Marine Laboratory, of the behavior of pink groove shrimp, *Penaeus duorarum,* in electrical field. The experiments showed that interrupted direct current caused the shrimp to move toward the anode. At present the findings have no practical application because power requirements are too large, but the experimentations along this line are of value because of the possibility of using electric currents in directing the movements of shrimp toward traps or nets.

Spiny lobster fishery is of great importance to the Caribbean area. Success of the fishery is much dependent on a knowledge of the behavior and movements of the crustacean. This information was obtained by tagging experiments conducted by C. P. Idyll and Charles Dawson of the Miami Laboratory. It was found that adult *Panulirus* migrates along the shores of the coast of Florida, covering the distances varying from a few to almost a hundred miles. Development of the lobster was studied by John B. Lewis of Miami, who gave detailed description of the eleven developmental stages and found that pelagic lobster larvae, *Phyllosoma,* drift northward from the tip of Florida and are dispersed in the open ocean by the prevailing currents.

A new chapter in the study of plankton has been written by Dr. Hilary B. Moore and his associates at Miami in the analytical studies of the zooplankton of the Florida Current and the determination of the physical factors which control its vertical distribution. John B. Lewis made a study of standing crop and of the environmental conditions affecting zooplankton, 40 miles east of Miami. His observations disclosed small seasonal changes, marked diurnal migrations and extreme deficiency of water both in the inorganic phosphorus and inorganic nitrogen.

Shellfishery research of general interest was concerned primarily with the studies of *Dermacystidium,* which is claimed to cause widespread epizootic

in the Gulf and South Atlantic waters. Valuable contributions about the pathology and life history of this fungus-like parasite of oyster made by Sewell Hopkins, Sam Ray and others, greatly advanced our knowledge about the disease affecting a large percentage of oyster population in southern waters.

Sponges from the eastern part of the Gulf of Mexico were identified, and some of them redescribed by the foremost authority on this group M. W. de Laubenfels. The list indicates 52 species, of which 11 species are new.

For some strange reason, marine fungi have failed to attract the attention of microbiologists. Very little is known about this important group of organisms capable of producing specific and highly potent chemicals. This gap has been partially filled by the work of S. Meyers on the marine fungi of Biscayne Bay and by observations of T. W. Johnson on the development of common brackish water species, *Leptosphaeria discors*.

Local surveys of the Cedar Key area, Tampa Bay and Biscayne Bay, conducted by the Miami Laboratory, provided better understanding of the ecological conditions in these areas. The data are most useful for the management of local living resources and for the control of pollution.

The problem of the Red Tide is of paramount importance to coastal communities of the Gulf States. Practical consideration demands that some effective method of controlling the disastrous outbreaks of blooming caused by *Gymnodinium* and associated organisms be found and applied to prevent the spreading of red water. On the other hand, it is doubtful that a satisfactory method of control can be formulated without an understanding of the basic conditions which cause the overproduction of *Gymnodinium* and other toxic microorganisms. Federal, state and private organizations continued to work on this problem, which fundamentally is the problem of oceanic productivity. The organism responsible for the outbreak was identified and cultured. Oceanographic conditions preceding the outbreak were studied and attempts were made to correlate the Red Tide phenomenon with the pattern of movements of coastal waters, with the phosphorus and nitrogen contents of sea water, with the composition and abundance of plankton preceding the outbreaks, etc. Several theories and hypotheses were advanced, but the problem of Red Tide is still far from being solved. Time does not permit me to discuss in any detail the present status of these studies.

An interesting suggestion regarding the conditions which may stimulate the Red Tide was made by H. T. Odum, J. B. Lackey, I. Hynes and N. Marshall in a joint investigation sponsored by the University of Florida and Duke University. On the basis of the data accumulated during the outbreak of Red Tide of 1952 to 1954, the authors attached significance to the differences in the N/P ratios in various harbors and bays and suggested that "there is a possibility that the increasing multiple pollution of the shallow coastal estuaries and land drainage may be producing a higher incidence of the Red Tide phenomenon than might otherwise occur." It is clear that Red Tide is a very complex phenomenon, in which several environmental factors combine to produce a sudden outbreak. It appears to me that the key to the solution of the problem, and therefore to the practical method of controlling it, lies in the studies of the growth requirements of Red Tide organisms, of their associations with other microorganisms, and in the biochemistry of the toxin.

Industrial and sewage pollution of harbors and bays continued to be a public menace threatening both health of human population and the existence of

coastal living resources. Surveys made during the past ten years by public health authorities showed that for some time the Galveston Bay and the Mobile Bay were grossly polluted and that shellfish from these areas became unfit for human consumption. Extensive pollution of Biscayne Bay has been also demonstrated by the survey conducted by the Miami Laboratory. Only enlightened public opinion may stop this willful destruction of our water bottoms and shores. Methods of combating pollution are too well known and require no special scientific studies. It can be added, however, that two additional sources of pollution threaten our inshore waters—namely, the ever increasing amount of detergents which find their way into natural waters and the disposal of radioactive wastes. Biologists and state conservation officials should be on guard of this new danger.

As it is apparent from my brief review of scientific achievements in fishery biology, the work carried on during the past decade dealt primarily with fact finding, description of the existing resources and in operational studies.

Scientific research of the Gulf biological problems has not yet advanced far enough to give an explanation of the many peculiarities of the Gulf. One of the intriguing questions regarding the biology of the Gulf is concerned with the low productivity of its fishery resources, which at present yield annually only about one-quarter of a million pounds of fish meat. What are the reasons for such low production? At present no adequate explanation can be advanced. It is known, however, that the central and deep portion of the western part of the Gulf is almost barren in comparison with the eastern part. Hydrographic studies carried on by A & M Texas Foundation show the existence of a hydrographic barrier which separates the surface waters of the Gulf into two distinct parts. How this hydrographic peculiarity affects the abundance of fish life of the Gulf area is not known. The more productive areas of the Gulf are found at the Campeche Bank on the south, at several red snapper banks in the northwestern part and on the broad shelf extending along the west coast of Florida. It is reasonable to assume that the movement of water masses contribute the primary factor determining the productivity of the various parts of the Gulf, but it is a challenge to fishery biologists of today and tomorrow to determine the nature of interaction of various factors and their combined effects on productivity.

Science cannot progress without the means of communicating its findings to other scientists and laymen. The Gulf area is lucky that the establishment of the "Bulletin of Marine Science of the Gulf and Caribbean" provides this outlet for publication of scientific findings and theories. Likewise, a series of popular pamphlets issued by the Miami Laboratory, the publication of the "Proceedings of the Gulf and Caribbean Fisheries Institute" and the attractive issues of the "Sea Frontiers," issued by the International Oceanographic Foundation, fulfill the essential task of keeping the general public informed about the goals and achievements of scientific research. Institutions sponsoring these publications and the officers engaged in writing, editing, and publishing these journals deserve our deep thanks. Their unselfish efforts are dedicated to the idea of promoting human welfare through conservation and better utilization of living resources of the ocean. I wish to express my appreciation for their valuable efforts and achievements.

DISCUSSION

Review Session

Discussion Leader: JOHN S. ROBAS
Discussion Panel: GORDON GUNTER, A. J. HARRIS, ROBERT M. INGLE, JAMES N. MCCONNELL

Progress in Fisheries Technology in the Gulf and Caribbean Area, 1948-1957

LAWRENCE W. STRASBURGER

Robas: (Comment) I want to remind the audience that some of the equipment and many of the new techniques and discoveries described by Mr. Strasburger in his paper were first introduced at meetings of the Gulf and Caribbean Fisheries Institute.

Q. Harris: There is a shortage of shrimp. Do you think that the industry should step up its advertising in order to create more demand for the product in the face of this?

A. Strasburger: At the present time the industry cannot satisfy demand, but from a business standpoint they must do a certain amount of advertising in order to keep their products before the public.

Q. Harris: Do you think, because of the greatly improved technological methods, that the small shrimp boat is on the way out and that shrimping in the future will be done almost exclusively by the large shrimp boats?

A. Strasburger: There is a definite trend in the direction of the larger boat. The small boatman, especially in Mississippi, Louisiana, and Alabama, can no longer make a living. I think that unless the white shrimp in the nursery grounds where the small boats have always fished, show a tremendous comeback, that the small boat is done for. There is too short a season for small brown shrimp in the shallow water areas to support a profitable fishery at present.

Schaefer: (Comment) I would like to comment on this problem of overfishing. Other things being equal, the fish or the shrimp will always be most abundant when there is no fishing at all. As the amount of fishing increases, the stock inevitably decreases somewhat, by virtue of the fact that the shrimp or fish caught are dead, and the next man can't catch them. So the fact is that the stock declines, and consequently the catch per boat declines as the fishing intensity goes up. If this is overfishing, then it is impossible to have any commercial fishery without overfishing, because a fishery which effectively exploits the stock will always decrease the total amount of the stock.

Another possible definition of overfishing, and one which is often accepted, is that it occurs when fishing becomes

intense enough so that the total catch declines. In this case, of course, the total catch will continue to rise for a long time as the catch per effort is going down. I believe overfishing should be regarded as occurring when the intensity of fishing is high enough to cause the fisherman to catch less fish than if he didn't fish so hard. A decrease in the total stock of fish, which is an inevitable consequence of any exploitation of any fishery, is not the proper definition of depletion or overfishing.

Idyll: (Comment) It may seem a little strange to be discussing biological questions as a consequence of Mr. Strasburger's paper on technology, but it is not strange at all. This question that has been raised concerning the wisdom of working hard to improve methods of catching fish on one hand while we are working equally hard to conserve the stocks on the other hand is one that continually plagues anybody that is involved in the study of fisheries. Are we actually working against ourselves? We can resolve this problem if we put it on this principle, that we must increase the efficiency of the operation. This is the only way the fishing industry can survive. It comes down to economics, and to the fact that no one attempts to exploit a fishery unless he can make a profit. He can't make a profit unless he can produce fish at a price that will be comparable with competing products. We sometimes lose sight of the fact that fishing must be made economical and efficient. Any apparatus that increases the efficiency is desirable. This isn't to say we are to allow fishing apparatus to operate even if it is destructive, but as Dr. Schaefer brought out, we must be careful of our definition of what is destructive. The way to resolve the problem to promote efficiency and still conserve the stock is not to discriminate against efficient pieces of gear, but to protect the fish in some other way, either by putting a limit on the total amount of fish caught, putting a limit on the size that is caught, so that we get the best size that brings the most profit in the markets, or by similar regulations. I think that we can, with clear conscience, continue to develop efficient pieces of gear and at the same time work out a technique for protecting our fisheries.

Q. Anderson: You said, I believe, that fresh menhaden produced a yield of higher protein content. Can you give us some idea of the magnitude of this increase?

A. Collins: I can give you a figure based on what was given to me by some of the companies in Pascagoula. They say that they get approximately a two to three per cent increase in protein from fresh fish compared with the yield from somewhat deteriorated fish.

Q. Saenz: What is the effect of the pump used for unloading shrimp on the texture of the shrimp?

A. Strasburger: There are two uses to which pumps have been put in the shrimp industry. One is in unloading the shrimp from the holds of boats. But from information which I have received, there is little or no damage to the shrimp. Of course, at that time the shrimp are still in their shell and damage to the shell should be slight. Food pumps are also used in the canneries for the peeled meats. Here you will find that there is a divergence of opinion. Some of the pumps which have been used have broken and torn the shrimp to some extent. If certain modifications are made on these pumps there is no damage to the shrimp.

Progress in Fishery Economics in the Gulf and Caribbean Area, 1948-1957

Richard A. Kahn

Q. Robas: Dr. Kahn mentioned this morning that by 1975 our population would increase by one-sixth. If we consume sea food at the present rate we must produce one-sixth more fish. How are we going to produce the extra fish to feed these people? Are we going to be able to make our gear more efficient to produce this extra fish?

A. Ingle: Some of this is going to come from an increased use of species now not used. Also, we have an ever-increasing demand in Tallahassee for permits for different kinds of gear. When, in the opinion of the Director, such permits can be issued without doing harm, or at least on an experimental basis, we permit people to use gear which either is not specifically permitted, or in some cases is even banned. One outstanding example is the use on the West Coast of Florida of the California lampara net for sardine-like fishes. But we have known for many years that there are several species of herrings off the West Coast of Florida, which have been used to a small extent as bait by sport fishermen. There is now developing quite a fishery for those animals. There is also some hope that this gear may be able to catch mullet, and also mackerel, perhaps for a fraction of a cent a pound.

Q. Robas: We do not eat menhaden in this country. But I know from experience, in the Caribbean area, where salt dry fish is regarded as a delicacy, the price of bacalao is so high, that any salt dried fish of good quality is saleable. Can anyone give us an idea as to whether he thinks menhaden will ever be an article of food?

A. Gunter: During the past war, myself and a number of people did experiment with menhaden as human food. I found that you can fry the fish in its own oil—you don't need any extra grease. The Fish and Wildlife Service made experimental shipments to Great Britain of menhaden canned

and labeled under the name of "Silver Herring." The British sent word back that they would take all the Silver Herring that could be sent to them. So during the war two canneries operated on the Atlantic Coast. After the war, the British market disappeared and the U. S. Food and Drug people told the menhaden canners that they would have to advertise their canned fish under the name of menhaden and not Silver Herring. Well, menhaden means fertilizer to most people, so they couldn't sell the menhaden. But I think the day will come when we will utilize them for food.

Aska: (Comment) I think we are getting the cart before the horse. We are assuming that we are going to have one-sixth additional market for fish in a few years. But it will take a lot of work if these extra people want to consume one-sixth additional fishery products. We must not overlook the fact that other countries are extremely interested in the U. S. market. I am wondering if our problem will be to find one-sixth more fish or to sell the amount of fish we are catching right now. For instance, we don't have the over-supply of the things that the customer wants, such as shrimp and lobster, but we do have a serious over-supply of a good many low priced items.

Robas: (Comment) The man with the forty or fifty foot trawler on the Atlantic Coast lives a very precarious existence. I think that the future for the shrimp fisherman will lie in his ability to catch something besides shrimp. A shrimp trawler must soon be not a shrimp trawler alone, but also must be a purse seiner or a lampara seiner for food fish. I think that that is going to be the salvation of some of our fisheries.

Progress in Fisheries Education in the Gulf and Caribbean Area, 1948-1957

C. P. Idyll

Q. Harris: Would you comment on Public Law 1027, on Vocational Education?

A. Idyll: This is part of the Payne Bill. The Payne Bill was in two parts, one to support education at the secondary level and for vocational education, and the other part was for professional education at the university level. We are interested in both of those, and we are disappointed when half of it, namely, the professional part of it, fell by the wayside in the last Congress. The first part of it is in effect. I think that we can look forward to quite a lot of activity in the training, first of all, of fishermen, and secondly, of people who would go into the fisheries as a profession. One of the handicaps that the industry labors under is the shortage of good fishermen, and mostly of good skippers. Certainly,

here is an area where practically all the research organizations and schools can be of big help, because it isn't too difficult to improve a skipper's efficiency by pointing out some of the new developments in science and technology which he has not had a chance to discover for himself. A profitable direction that our fishery education might take would be to train fishermen in this respect. The rest of the Payne Bill that was designed to support professional education passed in the last Congress, but it died simply because no money was provided for it. I have every expectation that this will be put up again for consideration and whether it comes through this time or some years from now, I am fairly certain that this will eventually be passed and we will reap the benefits from it.

Q. Harris: Do you think that the teaching of professional fisheries should start at the college level or high school level?

A. Idyll: I don't believe the teaching of professional fisheries should start until post-graduate level. The philosophy at our own university is that a man can't become a fishery scientist until he becomes a scientist. We go under the theory that he should have a sound training in one of the sciences, preferably one of the biological sciences, before he begins to specialize. And when he has been taught the techniques of sciences and the methods of logical thinking that are supposed to mark the scientist, then we think that he may be ready for specialized work.

Aska: (Comment) Whereas the original Payne Bill called for $375,000 for "vocational training and distributing trades therein—," which I think are some very important words—actually the Congress appropriated $228,000. That money was allocated to the states on the basis of five factors: one, the volume of the catch; two, the value of the catch; three, the number of fishermen; four, the number of shore workers, and five, the value of the manufactured product.

Q. Robas: Would you give us some information briefly about your experience at Fort Myers in running the fishing school which The Marine Laboratory sponsored?

A. Idyll: We had a double purpose at the Fort Myers school. One of the things that we are faced with in training professional fishery people is that we can't get the students to train. We had the idea that if we caught the youngsters in the high school and exposed them to some of the interesting things that are part of marine science, that we might, when they got to college, get them into science courses. Then, after a considerable period, if they survived all this treatment, we might get them into graduate school and make fishery scientists out of them. So this was one of our purposes. The other, of course, was to see if we couldn't fill the need of supplying skilled fishermen. So we thought that we could take some kind of skills to these high school youngsters and

persuade them that the trade of fishing was as interesting and lucrative a trade as some of the others that they might more normally find themselves in.

I think perhaps the most useful thing we can do for the vocational education in the fisheries of Florida would be to run some short courses for fishermen, perhaps something like those that are run by the University of British Columbia. They have successfully run short courses for fishermen, wherein they bring in qualified fishermen, chosen by their own groups, to come at no expense to themselves to take a short course in such things as navigation, engine maintenance and repairs, net preservation and any other thing that a fisherman must be proficient in. These courses are taught at the University of British Columbia in Vancouver by experts. They go back then to their areas and they are expected to pass along these skills and new information to their fellow fishermen.

Progress in Fishery Biology in the Gulf and Caribbean Area, 1948-1957

PAUL S. GALTSOFF

Q. Ingle: I wonder if anything can be done to expedite the quicker publication of research results.

A. Galtsoff: It is very unfortunate that often money is allocated for research with no definite provision for funds for the preparation of the report and for its publication. Very often the fault is in the failure to include this item in the budget. I think also we should allow more time to define the problem we are trying to solve, and to determine the type of observations we should make and this will eliminate the unnecessary observations.

Q. Harris: What do you consider the most important fisheries research carried on in the Gulf during the past ten years?

A. Galtsoff: The two most important projects in the Gulf area during the past ten years have been those concerned with the biology and ecology of shrimp and with the red tide. These efforts have not yet resulted in the solution of the problems, but they are important because of their significance for Gulf fisheries. The red tide problem is important because it deals with the fundamental manifestations of life in the ocean. Its study goes beyond the problem of control. I can't visualize how a phenomenon of such a magnitude can be controlled without first obtaining complete understanding of the fundamental forces causing its outbreaks. At the same time, I fully realize that for practical purposes it is very desirable to treat the problem symptomatically and at least partially reduce its effects.

TUESDAY—NOVEMBER 12

Chairman—JOHN C. FERGUSON, *President, Southeastern Fisheries Association; President, Shrimp Association of the Americas; St. George Packing, Ft. Myers, Florida*

The Shrimp Resources of Continental Latin America

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THIS DISCUSSION WILL COVER briefly a vast area extending between Mexico and Argentina on the Atlantic and Mexico and Chile on the Pacific. In this region there are at least twenty-one species of commercially important shrimp that inhabit coastal waters to depths of forty fathoms or less. The discussion will be restricted mostly to these shallow water forms, since the shrimp fisheries of Latin America, other than Chile, are almost entirely on shrimp occurring in depths under forty fathoms.

Shrimp belonging to the family Penaeidae account for almost all the shrimp catch in the area under discussion and ten species belonging to the genus *Penaeus* furnish about 90 per cent of the total catch. Fisheries in Continental Latin America for shrimp of this genus extend along the east coast, from the Gulf of Mexico to southern Brazil, and along the west coast from Baja California to northern Peru. It is quite evident that the range of *Penaeus* is considerably more extensive along the east than the west coast of Latin America. Shrimp of this genus are warm water forms and apparently upwellings, cold currents and other environmental factors restrict their range along the west coast.

Throughout the entire area the distribution of these shrimp is by no means uniform. There are areas where shrimp are abundant and can or do support commercial fisheries of considerable magnitude. There are also vast areas where the shrimp are scarce and apparently so scattered that commercial fisheries cannot be undertaken profitably. Most of the Caribbean Sea and much of Brazil's waters fall into this latter category, as also do the rocky and precipitous coastal areas of the Pacific. Where shrimp are abundant and fishing is commercially feasible, fisheries are already in existance today. In most instances those areas not now producing shrimp are areas in which shrimp are not present in sufficient concentrations. In some instances other factors have made it impossible to develop fisheries to their commercial potential. Some of these factors are lack of shore and transportation facilities, currency and export controls, and nationalistic laws.

In this immense area I do not know of any portion that has not been explored to some extent by fishermen using modern trawlers and gear. With the present prices and demand for shrimp, practically all the areas that can be fished profitably are under exploitation. The degree of exploitation, of course, varies considerably with locality. Some areas are being very heavily fished while others are relatively untouched. It is estimated that about one hundred fifty million

pounds (heads on weight) of shrimp, were landed in this area during 1956. This estimate does not include shrimp taken in the area by United States fishermen and landed in United States ports. The only catches of any magnitude of this latter type were from the Gulf of Mexico. The annual potential of the area is at least 200,000,000 pounds, heads on weight, and probably will exceed 300,000,000 pounds when the fisheries are fully developed.

Starting with Mexico and proceeding southward the fishing grounds will be listed and an attempt made to estimate the potential of these areas. It should be stressed that estimates of potential are based on personal observation and experience. In many instances the information available was by no means complete.

Mexico

On Mexico's west coast there are three separate fishing grounds. One is found along the Pacific side of the southern portion of the Peninsula of Baja California. The second extends, with some gaps, from the head of the Gulf of California along the mainland coast south to about San Blas, Nayarit. The third is in southern Mexico and encompasses the region between Salina Cruz and the Guatemalan border. In the Gulf of Mexico the Mexican fleets generally range between Soto la Marina and Campeche.

Mexico appears to have about reached maximum production. The production now depends on the biological potential of the various species of shrimp, rather than on the number of fishing boats. This is particularly true on the west coast of Mexico, where for the past five or six years the catches have been fluctuating, apparently in direct relation with the crop of shrimp produced each year. The only supply of shrimp that is not now being utilized to full capacity seems to be *Penaeus brevirostris* (red or pink shrimp) occurring in depths beyond forty fathoms, where the fleet does not operate. Many of these shrimp are too small in size to be commercially attractive at present. Expansion in this area will depend on market demand for small shrimp. On the east coast of Mexico both United States and Mexican fleets are operating in the Gulf of Mexico. Between them they are apparently catching most of the available annual crop of shrimp. Mexico's shrimp fleet in this area is expanding rapidly and it can probably be expected that the proportion of the available supply of shrimp caught by Mexican boats will increase.

At present the total Mexican catch is fluctuating between about eighty and one hundred million pounds a year, heads on weight. Future production should continue more or less within this range unless the possibilities mentioned become actualities.

British Honduras

British Honduras has been relatively well explored but the shrimp supply has not been sufficient for the establishment of an export fishery. White shrimp, probably *Penaeus schmitti,* and pink shrimp, *Penaeus duorarum,* have been reported from this area. The better grounds are in the southern part bordering on the Caribbean coast of Guatemala. This area might produce two hundred thousand pounds a year eventually.

Guatemala

The east coast of Guatemala is restricted in area and is typically Caribbean—

that is rather unproductive. It is not likely that a fishery of any magnitude will develop in this region. The west coast has much better prospects, even though it is rather formidable in that there are no harbors which boats can enter for unloading or refuge. There are nursery grounds scattered all along the west coast and castnet fishermen take about 50,000 pounds of shrimp a year from them. Exploratory commercial operations started this year on the west coast. The potential is estimated at between 1,000,000 and 3,000,000 pounds annually.

Honduras

Honduras now produces very few shrimp and most of these are taken with castnets in the Gulf of Fonseca on the Pacific coast, where *P. occidentalis* (white shrimp), *P. stylirostris* (blue shrimp) and *P. vannamei* (brown shrimp) are encountered. Owing to the limited Pacific coast line there is not much probability that Honduras will increase her catches in this area. Trawling operations along the Caribbean coast of Honduras have produced both pink and white shrimp, but apparently the shrimp school only occasionally. The better grounds are to be found in the eastern area, but as yet they have not been sufficiently rich to attract an enterprise. This region probably could produce five hundred thousand pounds a year.

El Salvador

El Salvador is in a better position to develop a shrimp fishery than many of the Central American countries. She has no Caribbean coast line, but she does have a good harbor in the Gulf of Fonseca and some rather good shrimp nursery grounds between the Lempa River and the Gulf of Fonseca. For the past several years trawlers have been operating in Salvador. This year a freezing ship was added to the fleet and El Salvador began exporting frozen shrimp to the United States. The trawlers catch six commercial species of shrimp *Penaeus stylirostris, P. occidentalis* and *P. vannamei* which grow to a large size and *Trachypeneus byrdi, T. faoe* and *Xiphopenaeus riveti* which are smaller. An estimate of potential is between one and three million pounds annually.

Nicaragua

Like many of the other countries, Nicaragua is enigmatic with respect to shrimp potential. Along the Caribbean coast about a hundred thousand pounds of shrimp are taken annually and a few are taken along the Pacific coast. The Caribbean coast appears to have a greater potential than does the Pacific. White and pink shrimp have been taken by trawlers experimenting along the Caribbean shores but here again the catches have been reported to be sporadic. Occasionally concentrations of shrimp would be found and then there would be long periods when only scattered individuals would be taken. The Pacific coast lacks nursery ground areas and cannot be expected to produce shrimp in any quantity. The potential of the country is probably about two or three million pounds annually.

Costa Rica

Costa Rica for the past several years has been exporting frozen shrimp to the United States. These come from the Pacific coast and are mostly *Penaeus occidentalis* and *P. stylirostris*. The Caribbean side is not producing shrimp for export and there is not much likelihood that it will in the near future. In the Pacific the fishing grounds are limited to three relatively small areas owing to the pre-

cipitous nature of the coast. The potential is probably between two and three million pounds a year.

Panama

Panama's shrimp catch all comes from the Pacific. Here eight species of shrimp are taken commercially. The more important are *Penaeus occidentalis, P. stylirostris, P. vannamei* and *P. brevirostris*. There are two major fishing areas on the Pacific coast, the Gulf of Panama, which is the more important, and the area between Punta Mariato and the Costa Rican border. The Panamanian shrimp fleet has been increasing rapidly during the past year. In mid-June 1957 there were one hundred fifty-seven trawlers in operation and at least fifty more under construction. It is likely that Panama will soon be reaching maximum production for shallow water trawling. There still remains the unknown potential of the pink shrimp *(P. brevirostris)*. The Panama pink shrimp appear in abundance in the shallower areas of the Gulf of Panama generally between December and April. Their appearance is associated with upwellings which bring colder water near the coast during this season and probably represents a shoreward movement of shrimp which normally inhabit waters colder than those present along the coast during other times of the year. Explorations have not been sufficient to determine the area normally inhabited by these shrimp nor to permit a reasonable estimation of their abundance. Nevertheless, Panama probably has a potential of between fifteen and thirty million pounds of shrimp a year. The 1956 production is estimated to have been about thirteen million five hundred thousand pounds.

Colombia

Colombia has shrimp fisheries on both the Caribbean and Pacific coasts. The Caribbean fishery, which produces between six hundred thousand and one million pounds a year, lands *Penaeus schmitti* (white shrimp) and *P. brasiliensis* (brown shrimp). Most of these shrimp are caught by primitive methods in the estuarine waters near Barranquilla. Various trawling experiments along the coast have not produced shrimp in commercially feasible quantities. In the Pacific where *Penaeus occidentalis, P. stylirostris, P. vannamei, Xiphopenaeus riveti, Trachypeneus byrdi* and *T. faoe* occur, the trawling grounds are better. They extend between Cabo Corrientes and the Ecuadoran border. The best grounds appear to be in the south near Tumaco. Owing to governmental policy, shrimp exports to the United States, which were running about three hundred fifty thousand pounds a year during 1954 and 1955, dropped to around one hundred thousand pounds in 1956. Present Colombian policy is more favorable and exports are expected to increase. The Colombian potential is estimated to be between ten million and twenty million pounds a year.

Ecuador

Ecuador has two principal shrimping grounds. The northern one is between the Esmeraldas and the Colombian border and the southern is centered around the Gulf of Guayaquil. The same species occurring on the west coast of Colombia are also taken in Ecuador. In addition *Protrachypene precipua* is caught both for local and export consumption. Ecuador's shrimp catch and exports are rising. It is estimated that over three and a half million pounds of frozen shrimp were exported to the United States in 1956. The annual po-

tential is estimated to be between ten million and twenty million pounds, heads on weight.

Peru

The Peruvian shrimp grounds are restricted to about thirty miles of coast adjacent to Ecuador. It is probable that many of the shrimp taken in Peru are migrants from Ecuador. Annual potential is estimated to be between a million and a million and a half pounds.

Chile

The Chilean shrimp fishery is of little significance. Local figures show that in recent years the best catch was made in 1954 when a hundred and one metric tons were caught. The shrimp are mostly pandalids taken in depths between eighty and three hundred fathoms. They are consumed locally. Chile is exporting frozen cooked peeled "langostino" tails to the United States. The langostinos belong to the family *Galatheidae* and are sometimes called plated lobsters. They are taken along the central coast of Chile in the same general area as the hake. Very little is known about the life, habits and abundance of langostinos. The 1956 catch was over eleven and a half million pounds, heads on weight, but since the cephalothorax, or head, is considerably larger than the abdomen, or tail, the yield of edible meat is considerably less than that of shrimp. It is probable that the langostino catch and exports will continue to rise. The shrimp catch, however, which is about two hundred thousand pounds, probably will not increase appreciably in the near future. The shrimp potential is estimated to be two million pounds annually.

Argentina

Two species of shrimp, *Hymenopenaeus mulleri* and *Artemesia longinaris* appear in the Argentina shrimp catches. Both are pink in color. *Artemesia* is considerably smaller than *Hymenopenaeus,* which is related to the royal red shrimp of the Gulf of Mexico. The shrimping grounds extend from about Mar del Plata, which is near the mouth of the River Plate, southward into Patagonia. The best grounds for *Hymenopenaeus* are reported to be near the town of Rawson in depths of less than ten fathoms. The annual catch fluctuates widely, apparently because of changing availability. The best year was 1952 when about five million eight hundred thousand pounds, heads on weight, of *Hymenopenaeus* were caught. The annual Argentine shrimp potential is estimated to be about ten million pounds.

Uruguay

Uruguay does not have a shrimp fishery nor is it very likely that one will be developed in the near future. Apparently shrimp of the genus *Penaeus* encounter the limit of their range along the coast of Uruguay. Occasionally, *P. brasiliensis* is found in some of the lagoons along the northern coast. Potential production is insignificant.

Brazil

Brazil, today second to Mexico in Continental Latin America in shrimp production, consumes practically the entire catch at home. The principal shrimp fisheries are in northern Brazil near the mouth of the Amazon River, where

Xiphopenaeus kroyeri, Penaeus aztecus and *P. schmitti* are taken, and in southern Brazil from a little north of Rio de Janeiro to Rio Grande Do Sul, where *P. brasiliensis, P. aztecus, P. schmitti, P. duorarum* and *X. kroyeri* are found. Brazil's annual catch is estimated to run between twenty and twenty-five million pounds, heads on weight, a year. The Brazilian potential is enigmatic. On the northern grounds the seabob predominates. Apparently more than half the catch now taken by trapnets and stop seines in this area is this species, which generally is too small for commercial acceptance in the United States. Young white and brown shrimp also appear to be abundant in certain portions of the nursery grounds in this area, but whether they can be taken profitably by otter trawls at larger sizes is still somewhat doubtful owing to the nature of the bottom and the tidal ranges. We shall know a lot more about this area within the next few months, since quite recently a trawling and freezing operation was started with its base in Belem. In the southern fishery trawls have been used for a number of years in the area around Rio de Janeiro and Santos. Farther south most of the shrimp are caught in the lagoons and estuaries by castnets, stopnets and seines. Here again we should soon know much more about the productive capabilities of the area, since recently a Japanese trawling fleet, based in Santos, started operating. The Brazilian shrimp potential is estimated to be between sixty million and one hundred million pounds annually, but it could go considerably beyond this.

The Guianas

In the three Guianas the seabob *(Xiphopenaeus kroyeri)* predominates in the French and Dutch areas, but in British Guiana two very small shrimp, locally known as "white bellies" or "fine shrimp," are most abundant in the estuarine catches. These are *Palaemon schmitti* and *Hippolysmata oplothoroides*. White shrimp, *Penaeus schmitti,* and brown shrimp, *P. aztecus,* are also occasionally taken in the estuarine fisheries, and recently the pink-spotted shrimp, *P. brasiliensis,* has appeared in offshore experimental-trawl catches, although not in great abundance. The current catch for the Guianas is estimated to be about two million pounds a year and the potential about fifteen million pounds, mostly of shrimp of small size.

Venezuela

The Venezuelan shrimp grounds are widely separated. The most productive area is in the west in Lake Maracaibo and the Gulf of Venezuela, where *P. schmitti, P. brasiliensis* and *P. aztecus* are taken with trawls and castnets. The remaining fisheries are found in the lagoons of central and eastern Venezuela where seines and castnets are used. Apparently *Xiphopenaeus kroyeri* becomes more abundant towards the east and probably predominates in coastal waters around the mouth of the Orinoco River. From descriptions of shrimp taken in the tidal zone of the Orinoco it is probable that the very small *Palaemon* and *Hippolysmata* predominate on the Orinoco nursery grounds as they do in British Guiana. The Venezuelan shrimp production is estimated to be about two million pounds annually and the potential to be eight to ten million pounds.

The Shrimp Industry of Panama

RICHARD EISENMANN

Panama City, Panama

"PANAMA" is supposedly an old Indian word meaning, "abundance of fish," yet it was not until 1950 that there began the development of what may be called an industry. Previous to that time most fishing was by hook and line, and what little shrimping was done was accomplished by cast nets in shallow water. Shortly after the second World War, shrimp trawling was started. All the shrimp caught was sold locally. From this development, in 1950 approximately 13 power boats were shrimping with trawls. No winches were used at that time. The catch was extremely high, and before the end of 1950 old boats were bought in the United States with complete equipment. The first freezing was done and export started. By the end of 1957, there were approximately 200 boats operating in Panama, more than half of which were 60-foot boats.

The "Super Jumbo," Panama's best known shrimp, consist mostly of a *Penaeus occidentalis*. Some *stylirostris* and *vannamei* are also caught. These are all called white shrimp in Panama. The following sizes are normally caught in Panama. Forty-five per cent under 10 count (heads off), approximately 50 per cent 10 to 15 count, approximately 4 per cent 16-20 count, and approximately one per cent smaller sizes. There is a small catch of a little brown shrimp *Xiphopenaeus riveti,* the size range of which is 41-50 to 60-70's. At least 80 per cent of these are peeled and deveined and shipped as shrimp meats. In certain months of the year, and only in some years, very large catches are made of a pink-red shrimp, *Penaeus brevirostris,* and although they are not as large as 16-20's, the majority of the females are 21-25 size, while the males run 40-50.

The greater part of the shrimping is done in the Gulf of Panama, which is shaped like a bowl. In the center of the Gulf is the fishing port of Panama City, The outermost point of the Gulf, as travelled from Panama City, is approximately 120 miles. The entire Gulf falls well within the 100 fathoms depth range, and approximately 50 per cent of it has a depth of less than 40 fathoms. Probably 25 per cent is under the 20-fathom range where most of the shrimping is currently done. Approximately 50 per cent of the area of the Gulf has a bottom of soft, smooth, gray mud. The Gulf is amply fed by numerous small rivers and streams carrying off the water from the eight months (about April to December) rainy season. It is during the dry season that northeast winds sweep the Gulf, moving surface water out. This is replaced by an upwelling of the deeper, colder waters. This movement varies from year to year with the intensity and duration of the northeast winds. The movement of water creates measurable changes in shallow water temperatures from a rainy season 80° to 70°. With the upwelling and consequent lowering of the water temperature the pink-red shrimp appear to move into depth ranges of 30 fathoms and less. This shrimp is caught in greater quantity at night, while the other shrimp are caught more abundantly during the day. With the dry season (December to March or April) there is generally a drastic reduction in the white shrimp catch while there is a somewhat compensating increase in the catch of the brown shrimp, and sometimes, as mentioned, of the pink-red shrimp.

Panama lies in the Belt of Calms. Thus, it is seldom that weather is too rough for shrimping. It is unusual when there are winds of more than five minutes

duration exceeding 27 miles per hour. However, at times especially during the equinox, there may be gusts of up to 40 miles. These gusts generally precede the beginning of a heavy rain, so that visual warning is available to the fisherman. Another peculiarity in Panama is the very large tides ranging from 11½ feet to slightly over 18 feet. As is typical in places where very large tides are the rule, the low tides leave large mud flats which, up to the present, restrict boat landings to a period of six hours on each of the two tides. The boats tend to enter port almost entirely on the night tides, except when this is reversed during periods when the pink shrimp is being caught. The result is that the industry in Panama works with the tides, and with the wax and wane of the moon. Shrimping captains prefer periods shortly following the full moon for fishing. Naturally there is some variation in shrimp location as tides change, since the amount of water moving with the tide is far greater than the normal wind-created currents.

The majority of the Panama-built boats are semi-V, 60 feet x 18 feet. The main engines are Caterpillar 342, although the 337 F is now being used extensively. GM 71 series engines are also strongly represented, but there is an even stronger tendency for those who like the GM to move into the 110 series. A new company is now building twelve boats which will have Cummings Diesels. Practically every winch used on a boat in Panama is a "Straudsburg," generally the 515½T. A growing number of the new boats are installing the larger "Straudsburg" winches. Most all other equipment on the boat is bought from a variety of the many U.S. manufacturers with the exception of batteries which are manufactured in Panama.

Panama shrimpers make wide and successful use of refrigerated sea water tanks following the original experimental work done by The Marine Laboratory of the University of Miami. Installation of such tanks was first made on Panama boats some three years ago when a number of the fleet went to Ecuador where ice was not available in quantity. The experience of these boats was uniformly good. In most cases the owners were the captains of their boats. Since the first successes with this technique there has been a constant conversion to seawater tanks on existing boats while at least 75 per cent of the new boats in Panama are built with chill tanks to carry approximately 10,000 pounds of shrimp. Four tanks are used and refrigeration is provided by a 7½ h.p. compressor powered by a pulley through a clutch and connected with the power take-off on the main engine.

Almost uniformly, boats with chill tanks bring in their shrimp in better condition than the boats still using ice. It has been found that three inches of insulation will keep the temperature down sufficiently for 24 hours after a breakdown in the refrigeration system—ample time for the boat to return to port. The problems raised by the use of the shrimp tank are comparatively easily overcome. We now have an electric bell alarm system if water in the tanks begins to ice up, leaving the shrimp exposed. On most boats the water in the tanks with shrimp is changed after six to seven days, being replaced by chilled water from one of the other tanks.

The boat that brings us shrimp in best condition follows this procedure: The deck is washed down and cooled by sea water before the catch is dumped on deck. Shrimp are headed as rapidly as possible, then washed, small quantities at a time in wire baskets, and as quickly as possible put into the tank with sea water between 30°F and 40°F. Daily inspections of the water in the tank

with shrimp are made by the captain, and he is able to tell when the water needs to be changed by noting when it ceases to be completely clear. This captain does not find it necessary to change the water in less than 10 days. He attributes this to the thorough cleaning he gives the shrimp and the speed with which he puts it below deck.

Such a refrigeration system costs approximately $3,000.00 per boat, installed. The cost of ice blown on board the boat is $10.00 per ton. The refrigeration system is economical, from the point of view of running cost, and gives the great added advantage that the boat need never return to port while drags are yielding large quantities.

Of particular importance to the boat owner in Panama is the catch of the small brown shrimp, which supplements his income. Boats which ice their shrimp cannot carry these shrimp for more than three days with heads on. The "acid" in the body fluids of the shrimp and the thornlike projection on their heads is very hard on the fishermen's hands. These factors, and the sheer numbers of shrimp, make is impossible for them to head large quantities of the small shrimp. We have found that with the chill tanks these shrimp may be brought in with heads on in apparently perfect condition to the full length of the trip. Thus, while the ice boats can only bring in these brown shrimp from the last three days of their shrimping, the tank boats can utilize all they catch. Generally, the brown shrimp are caught while dragging for the white shrimp.

The net size on the majority of the boats ranges between 95 to 100 feet. A flat trawl is used with doors of 8 to 8½ feet in length. Cotton netting is still used by all boats, although there have been very successful trials made with Nyak nets. Dacron netting is also being tried, but the tests are not at all conclusive, due to the use of mesh that seems a little large; nevertheless, their strength and durability is already clear. There are five shrimp freezers, with one more being built. In all cases today the plants own at least one boat while approximately 50 per cent of the fleet is owned by firms or persons owning from one to twelve boats.

At present only one freezing firm has its own dock. Another is located across the street from a public dock. The new freezing firm which is being built is also building a dock of its own. Our own firm, Pesquerias Oceanicas de Panama, is now building a dock on which our plant itself will be located. In conjunction with the dock we will have a tidal pool which will permit the boats to enter on the two high tides each day and to remain at dock-side floating in the pool for unloading and repairs during the period of the low tide. This will facilitate operation of the plant as well as the maintenance of the boats themselves. It will offer considerable protection against ground swells which often cause damage by banging the boats against existing docks.

One company here is using its trash fish in a new fish-meal plant. For some time they have been utilizing their better fish in the production of fillets, which have been sold mainly to the local trade. We expect some further development of this fish trial, which will carry some of the shrimping cost. It is likely also that in the next few years the freezing companies will begin to use their seasonal excess freezing capacity for farm products. Panama is still, however, an importer of canned shrimp from the United States, as well as a volume importer of other fishery products.

The New Shrimp Industry of Washington*

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A RECENT EDITORIAL in the Bellingham, Washington *Herald* (Anon., 1957) stated:

> "Shrimp fishing has become an important Washington industry. Possibly few Washingtonians realize this state has passed California and now is the No. 1 shrimp state of the Pacific Coast. Two years ago, a United States Fish and Wildlife Service exploratory ship located huge quantities of shrimp on a shelf off Grays Harbor . . .
>
> "The Washington coast shelf is estimated to be 100 miles long and 15 miles wide. The tasty pink shrimp is there by the billions. Introduction this year of a mechanical shrimp peeler is credited with making Washington's shrimp commercially practicable. Now the industry is rated in the multimillion dollar class."

This, in an extremely condensed version, is the story of the Washington shrimp industry. An industry which produced but a few hundred pounds in 1955, a few thousand pounds in 1956, an estimated two to two-and-one-half million pounds in 1957, and which has an estimated sustained annual production potential of approximately twenty million pounds.

Historically, the pink shrimp *(Pandalus jordani),* which compose the bulk of the shrimp landed in Washington, have been known to be abundant off the Columbia River and off the Grays Harbor area since 1904 (Rathbun, 1904). However, the difficulties of profitably catching and processing large quantities of the small or "cocktail size" shrimp, which average 120 to 140 count heads-on per pound, prevented exploitation of the fishery. A local, relatively inconsequential industry developed in Washington utilizing the incidental catches of the otter trawlers and the production of a few pot fishermen. The shrimp, in general, were handled similarly to the Alaskan operations which have been existent since 1915 (Wigutoff, 1953). The whole shrimp, immediately upon receipt, were cooked in boiling fresh water, cooled, picked by hand, salted either by cooking for a few minutes in a 25°-30° Salinometer brine or by dipping in a saturated salt solution for a few minutes followed by cooking in steam. The shrimp were cooled again, blown by mechanical means to remove fragments of shell and antennae, and then packed in metal containers. These were shipped under ice to fresh markets or else were frozen and distributed as a frozen product.

The birth of what has been termed "the new shrimp industry of Washington" dates to the two exploratory trips by the United States Fish and Wildlife Service vessel, M/V JOHN M. COBB, in the fall of 1955 and the spring of 1956, and to the installation in November, 1956, of a single mechanical peeler in a cannery located at Westport, Washington.

The explorations, which were carried out in cooperation with the State of Washington Department of Fisheries, demonstrated that the shrimp were abundant along the coast of Washington (Schaefers and Johnson, 1957; Tegelberg and Smith, 1957). Catches of shrimp were recorded as great as 2,200 pounds per hour drag. The most productive bottom was found to be green mud or green mud and sand, and the better catches were obtained at depths of 60-85 fathoms. Perhaps the greatest significance of the exploratory trips was the dem-

*Contribution No. 25, School of Fisheries, University of Washington, Seattle, Washington.

onstration of the suitability and, in fact, superiority of the 40-foot flat Gulf shrimp trawl for catching of the pandalid shrimp.

Examination of the hauls, which in many cases were composed solely of shrimp, indicated that the protandrous pandalids begin life as males and change to females between the second and third year. The females may become egg bearing as early as the second year but, in general, do not become sexually mature until the third year. The egg bearing period of the year was found to be from late fall to early spring. Three separate year classes were reported to be present in the fall and four separate year classes in the spring.

Preliminary experiments concerning the keeping quality of the shrimp were made during the exploratory trips. The results of these experiments indicated that the shrimp could be held in ice for periods up to 96 hours with but slight changes in the texture of the shrimp meat either before or after cooking, or in the flavor and color of the cooked meat. However, after 48 hours on ice, the pink color of the whole shrimp was found to have faded to a paler shade. It was noted that the shrimp were easier to peel after a day on ice than when first landed.

Shortly after the results of the exploratory trips became known, an operation began in Westport, canning the shrimp rather than freezing them as had been done in the past. During the summer of 1956 production was limited because the shrimp were hand picked. The product found a ready market and demand for production increased. The installation of the first peeling machine (The Peelers Company, New Orleans, Louisiana) on the Pacific Coast north of Mexico which was capable of handling approximately 1,000 pounds per hour was the start of large-scale production ("Petrale," 1956).

The fishery in Washington is carried out by 40 to 70 foot boats with capacities up to 80,000 to 90,000 pounds. The Gulf Coast trawl with a 1.5 inch mesh is used extensively in Washington, which is the only state at present permitting the use of this type of gear. Generally, the crew consists of three or four men, including the skipper. It has not been uncommon for a boat to land 25,000 pounds of shrimp in a three day trip. The ex-vessel price, at present, in Washington is 7½ cents per pound of heads-on shrimp. Since the product retails locally at 39 cents per seven ounce can (4.5 ounces of shrimp meat), there is a satisfactory profit for all concerned.

Aboard ship, the shrimp are not headed but are given a preliminary washing and sorting on deck and then packed in shallow layers in ice in the hold. The present United States Fish and Wildlife Service recommendations, which are based on additional work beyond that of the exploratory trips, are that the shrimp be held no longer than five days and preferably for a maximum of three days in iced storage. Only slight differences in quality have been found to occur during the first three days of iced storage, but softening and discoloration become a problem during the fourth and fifth days. It is important, however, that the shrimp be iced at least overnight to obtain the best results from the peeling machine.

At the canneries the shrimp are stacked in shallow layers with ice. The first step in processing is the mechanical separation of the shrimp from the ice, which is accomplished by the first operation of the peeling machine. The shrimp are next peeled. The yield is approximately 20 per cent of the heads-on weight when peeling is done by the mechanical peeler and 25 per cent when done by hand.

There are two problems involved in the mechanical peeling operation. The

first is the excessive breakage which is due to the abrasive action of the machine and the extreme tenderness of the shrimp. The second is the loss of color of the shrimp, which is also due to the abrasive action and to the excessive use of water.

The raw shrimp are given a minimal cook which serves the purposes of merely coagulating the protein or, in other words, firming the shrimp. The recommended processes are either a two minute continuous exposure to steam at atmospheric pressure, or a 1.5 to two minute immersion in water at 212°F. The shrimp are next rapidly air cooled, either by exposure to still air in shallow pans, or in moving air. Following this operation, the shrimp pass through a fanning or blowing machine where fragments of shell and antennae are removed. The shrimp are then placed in wire baskets and dipped for 15 seconds in cold 50° Salinometer brine.

Many requests have been received by the packers for intensification of the color of shrimp which, as a result of the peeling machine action, are generally a very light pink. As a result, some canneries are adding food coloring to the shrimp. The United States Fish and Wildlife Service recommendations are at present, that if food color is to be added, it should be added either to the brine in which the shrimp are dipped, or that the shrimp be dipped for 10 to 20 seconds in a separate, cold color solution. The Service recommends a 1:10,000 concentration (one ounce of dry food coloring to 75 gallons of water) of the Imperial Orange shade (Crescent Manufacturing Company, Seattle) which is a blend of FD&C Yellow No. 5 (Tartrazine), FD&C Red No. 1 (Panceau 3 R), and FD&C Red No. 2 (Amaranth).

The shrimp are then drained and packed in 201x113 "C" enamel cans. The final steps in the processing are vacuum sealing and retorting, in accordance with National Canners Association recommendations (Anon., 1950) for 24 minutes at 240°F. followed by water cooling.

The "infill" of the cans is 4½ ounces of shrimp meat, 10 to 12 milliliters of 2½ per cent citric acid solution, and 2½ ounces of 10 to 15° Salinometer brine. The drained weight of the shrimp following processing should be 4.5 ounces and, while shrinkage is not a problem, the "cutout" weight should be checked since slight variations in texture and quality of the shrimp, and in the cooking and processing procedures of the individual canneries, will affect the shrinkage. Similarly, the salt content of the finished product should be checked, for personal tastes will differ and slight variations in the processes will affect the salt content. However, it is doubtful that a salt content greater than two per cent of the drained weight would be desired by the consumers.

The use of citric acid was originally suggested by Mr. L. G. Germain of the American Can Company, Seattle. The purpose of the citric acid is to lower the pH of the final product to approximately 7.0. It has been found that if the pH of the processed shrimp is greater than 7.1, there is a tendency for the shrimp to discolor, becoming grey, and to develop an off or undesirable odor which is reminiscent of the start of sulfide spoilage. Of course, if the shrimp are of poor quality at the start of processing, the citric acid will not control the sulfide breakdown nor the loss of color in the canned product.

The present United States Fish and Wildlife Service recommendations are that the pH of the final product be between 6.85 and 6.90. A fairly representative sampling of commercial packs available on the market indicate that the pH of the final products range from 6.9 to 7.1.

The two major technological problems which remain to be solved concern the shrimp texture, which is somewhat mealy, and the relatively short time it is possible to hold the shrimp in ice prior to processing. It is possible that an additive or an improvement in process could make the shrimp somewhat firmer. It is also possible that refrigerated brine holding of the shrimp could extend the storage life following capture. Work is being carried out along these lines by the Seattle Technological Laboratory of the United States Fish and Wildlife Service.

Even though the canning operations appear to have taken over the shrimp industry in Washington, fairly large quantities of the shrimp are still sold as a frozen product. Locally, the process is almost identical with that of canning. The problems of frozen storage and maintenance of quality have been discussed by Carlson and Dassow (1956), who concluded that the product could be maintained in excellent condition for a least nine months.

The pink shrimp industry, which at present is the most important shrimp fishery, is not, however, the only shrimp fishery of the state. Other species of shrimp found in local waters include the "side-stripe" *(Pandalopsis dispar),* the "hump-back" *(Pandalus hypsinotus),* the "prawn" or "spot" *(Pandalus platyceros),* the "coon-stripe" *(Pandalus danae),* and the other "pink" *(Pandalus borealis)* (Butler, 1950). In Washington, a small but growing industry (30,000 to 50,000 pounds per year) has developed, utilizing the "prawn" or "spot" from the waters of Hood Canal and the port waters of the city of Seattle (Elliott Bay). These shrimp generally range from 3 to 20 count of heads-on shrimp per pound, and the present ex-vessel price is 35 cents per pound. The shrimp, which are found on rocky bottoms and are captured by pots, are landed alive, boiled without heading or peeling, and sold in this condition as a fresh refrigerated product for the hotel and restaurant trade.

The other species of shrimp which were mentioned above, as well as the pink shrimp *(Pandalus jordani),* are distributed in greater or lesser quantities all along the Pacific Coast of North America. Local industries have developed wherever one or more of these species are captured in quantity. These fisheries have not expanded beyond local requirements because of the high labor cost of preparing the shrimp meat by hand methods. The major exploited areas for Pacific shrimp have been Bodega Bay, Eureka, and Crescent City in California, Coos Bay in Oregon, Grays Harbor and Willapa Bay in Washington, the inland waterways of British Columbia, and Petersburg and Wrangell in Alaska. The majority of the catch has either been frozen or sold on the fresh market. Now with the success of the Washington industry, expansion and exploration is going on throughout the whole Pacific Coast. New beds have been reported in British Columbia, supposedly equaling those found off Washington (Anon., 1954). Fantastic catches have been reported off the Alaskan Coast. The United States Fish and Wildlife Service exploratory vessel M/V TORDENSKJOLD, reported catches as high as 3,800 pounds per half hour tow with a 40-foot Gulf shrimp trawl in areas around the Shumagin Islands ("Petrale," 1957), and our own vessel, the M/V COMMANDO, landed 1,300 pounds of shrimp in a 20 minute drag with an otter trawl off Yakutat this past summer. In both cases, the catch was almost entirely shrimp. A conservative estimate of the potential of the Pacific shrimp fishery would be 100,000,000 pounds per year, most of which would be the pink or "cocktail type" shrimp.

At present California is the only state which has weight restrictions on the catch with an annual quota of one-and-one-half million pounds. Both Oregon

and California restrict the gear to a 20-foot beam trawl; in Alaska, the beam trawl is used extensively because of the type of bottom. The demonstrated success of the Gulf type shrimp trawl may change this situation. The Pacific Marine Fisheries Commission has under consideration minimum mesh regulations as a means of conservation, but sufficient information as to the occurrence and biology of the various species of shrimp is lacking for rational regulation of the fishery. At present, no regulations are under consideration either in Washington, Oregon, or Alaska. In the future, the situation may change and an area quota system or seasonal restrictions in addition to mesh regulations may be imposed on the fisheries.

At present there are six canneries in operation in the states of Washington and Oregon, four with two peelers, and two with one peeler each. The canneries in Washington are located in Aberdeen, Hoquiam, and Westport. In Oregon, two canneries are located in Warrenton, and one in Astoria. A third plant is planned for Warrenton, and an operation in Coos Bay is imminent. A cannery with a peeling machine is already in operation in Wrangell, Alaska, and an operation is planned for Petersburg.

The products are presently being marketed only west of the Rocky Mountains, and even with greatly increased production, the market shows no signs of weakening. Supposedly, the advantages of the use of artificial color decreases with the time of shelf storage. However, to date the turnover of the products has been so rapid there has been no test as to the true shelf life of the product.

With production potential excellent and a market which appears to be unlimited in that the majority of the United States has yet to be tried, the future of the Pacific shrimp industry is exceedingly bright. Whether or not Washington retains its position as the leading producer of Pacific shrimp is of relatively little importance. Of course, this would be desirable from the point of view of state pride, but of most importance is that the Pacific shrimp industry has been established and is expanding in Washington. As such, it has contributed a new source of income to our fishermen, our processors, our distributors and, therefore, to the material welfare of our state.

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Research on the Biology of the Tortugas Shrimp

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ABSTRACT

This is an interim report describing the program of biological research and some of the preliminary findings on the Tortugas shrimp fishery. Analysis of historical records of dealers selling only large shrimp brings to light the possibility that the trend in the average catch per boat per night for each year has not changed greatly since the fishery began. Also, the distribution of sizes landed by dealers has not undergone a regular change over this same time. A rather clear cut size-depth relationship existed early in 1957, i.e., the majority of small shrimp are found in shallow water and the majority of large in deep water. There is evidence to suggest that the fishery at times markedly reduces the number of various sizes of shrimp available. A program of tagging, using Petersen tags, to study growth and migration is described.

Shrimp Research by the U. S. Fish and Wildlife Service

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The biological studies of our shrimp laboratory encompass several types of work. Under general work, the compiling of a world-wide bibliography on the Penaiedae of over 700 titles will be submitted for publication within the next few months. Laboratory studies include determining the effect of different substrates on the rate of growth. Post-larval grooved shrimp reared on bottom covered with the stiff marsh grass, *Spartina alterniflora,* increased in length 122 per cent in 61 days, against 39 per cent when placed on bottoms covered with mud and 50 per cent on sand. These experiments are being repeated commencing with large shrimp, and already the *Spartina* covered bottom is proving superior. These experiments point out the desirability of maintaining vegetated marsh as nursery areas.

Preliminary work on reaction of shrimp to light gradients in a 12-foot tank show random movements by the white shrimp *(P. setiferus)* while the grooved shrimp *(P. aztecus)* preferred the extreme dark end of the tank.

Post-larval shrimp proved very tolerant of temperatures from 4° to 40°C. Post larvae only 12 mm long survived indefinitely at 40°C. Respiration experiments have been started to decide at what point oxygen deficiency becomes a limiting factor.

The work by Charles Dawson on the use of vital stains for marking shrimp has been published. He found red, green and blue stains that give good results. We have tested the red stain which can be fed to larval shrimp as small as 12 mm in a food mixture. After two months, 90 per cent of the marks were easily recognizable. All three stains can be used in shrimp from 30 mm and larger by injecting .01 to .02 cc. of a one per cent solution in artificial sea water isotonic to the water in which the shrimp are held. Twenty one hundred shrimp were marked and released and a few recoveries were made. Of the controls held the survival was: out of 50 green-dyed—31 in 3 months; out of 10 blue-dyed—5 in 3 months; out of 50 red-dyed—34 in 3 months. All controls, except three of those fed the red dye, were clearly marked after three months We are experimenting with another blue stain which appears to yield better survival than the one now in use.

Field studies are being carried out on shrimp while in the marshes and estuaries. One of the first problems was to discover how to obtain quantitative samples in the stiff marsh grass of the shallow waters. This was finally solved by development of a special push-type net on runners that efficiently samples young shrimp from 12 to 85 mm in length.

After preliminary reconnaissance we have selected Clear Lake as an ideal spot to determine the seasonal abundance of white and brown shrimp in an estuarine environment. By sampling at the inlet to the lake we can obtain accurate data on the inshore and offshore movements, and the changes in size within the lake will give needed information on growth. Incidentally, we often find large shrimp in these nursery areas and this raises the question of what factors induce them to leave the inside areas. For this reason we are collecting physical and chemical data to discover any clues.

Little quantitative data are available on the effect of predation in nursery areas, but we are studying the feeding habits of the sand trout, *Cynoscion arenarius;* and other estuarine fish, since shrimp are found in most of the fish stomachs examined.

The fishery for shrimp to sell as live or dead bait has become a major industry. In a special study of the Galveston Bay area, over 200 retail bait houses sold over 82,000 quarts of live shrimp, worth over $164,000 and 50,000 pounds of dead shrimp worth over $25,000 in a four month period for a total of over $190,000. The manpower shortage precluded obtaining complete coverage, so these figures are a minimum. Damage by hurricanes to the bait fishing fleet reduced fishing pressure considerably during one of these four months. In this area the catches of the bait fishing vessels have been sampled to obtain the size and species taken.

In the Tortugas area the Service has contracted with the University of Miami Marine Laboratory to determine by sea sampling from a chartered vessel the seasonal distribution of pink shrimp by size, sex, depth and area. Service personnel will also initiate a shrimp marking project from the vessel as soon as the logistic problems of large scale marking with vital stains have been solved.

The Corps of Engineers is presently drawing up sketches and cost estimates for installing a system of running sea water at our Galveston Laboratory to include a number of outdoor salt-water tanks. These semi-controlled conditions will enable us to obtain basic information on shrimp culture that would be very difficult to work out at pilot farms.

Pond Cultivation of Shrimp in South Carolina

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Cultivation of marine organisms in salt water ponds has been practiced in the Orient for five centuries or more. Growing shrimp in such ponds is common practice in many countries, but not in the United States. There are ample tidal marshes along the South Atlantic and Gulf Coasts where shrimp ponds could be built, and the possibility of shrimp cultivation is intriguing. The question is whether or not pond cultivation is economically feasible, and whether or not this method of producing shrimp can compete with trawling.

Detailed cost analyses of production of shrimp by pond cultivation, as against production by a trawler, are not available, but some generalities give an interesting picture. The modern seagoing shrimp trawler costs between $20,000 and $40,000. Shrimp ponds can be built for between $250 and $600 an acre. The cost of maintaining a shrimp trawler is considerable. Compared to this, the maintenance cost of established salt water ponds is negligible. Cost of operating a shrimp farm is unknown, but considering the operational cost of a shrimp trawler (crew's share, fuel, nets, gear, etc.), certainly a shrimp farmer would not be reduced to penny-pinching. Now the question becomes "Can the acreage of shrimp ponds which can be built for the same cost as a trawler produce annually the 20,000 to 50,000 pounds of shrimp caught by a trawler?"

So far as is known, no commercial shrimp farming has been tried in the United States and, therefore, commercial production figures are not available. Reports coming out of India indicate that from 350 to 1,000 pounds of shrimp are produced per acre of pond during a season of five months (Gopinath, 1955). Calculating from the general figures above, if the marsh lands of the United States could produce shrimp as is done in India, the equivalent cost of a shrimp boat put into shrimp farms would yield annually between 12,000 and 160,000 pounds of shrimp.

For the past ten years Bears Bluff Laboratories has been experimenting with the growing of shrimp in salt water ponds in the marshes of South Carolina. The records of these experiments give some clue as to the feasibility of pond cultivation of shrimp in the United States. Actually, the shrimp production in the ponds at Bears Bluff Laboratories has been a pasturing and fattening of stocked shrimp, rather than the raising of shrimp from brood stock. There is no evidence from the work in South Carolina to indicate that shrimp have ever spawned in the ponds. (However, see Johnson and Fielding, 1957). The experiments have been conducted in five salt water ponds ranging in size from a tenth of an acre to slightly more than an acre. Three of these ponds are built in the tidal marshes, two in the high land. The high land ponds are filled from a nearby creek with irrigation pumps. The tidal ponds are filled through flood gates. All are relatively shallow, about three feet in depth.

Apparently these ponds are a suitable habitat for marine organisms. One of the one-acre ponds yielded a harvest of 408 pounds of fishes, crabs, and shrimp in an eight month period (Lunz, 1956); another acre pond yielded an average of 250 pounds of marketable fish a year, over a five year period (Lunz, 1951); oysters have been grown satisfactorily and abundantly in one of the ponds (Lunz, 1955).

From the data available there are four records of harvests from the salt water ponds which give some clues as to the natural recruitment of shrimp in the ponds. The mean natural yield (no stocking, no feeding, no protection from predators) for these four experiments is an even 30 pounds of shrimp. The individual experiments cover cultivation periods extending from a minimum of 56 days to a maximum of 283 days. It is interesting to note that the shorter duration of time of cultivation yielded the higher poundage of shrimp (46 pounds, 8 ounces). There are two possible explanations for this: (a) less time for predators to eat the shrimp, and (b) the cultivation time did not extend through the winter months.

In addition to data from the ponds at Bears Bluff Laboratories, the salt water pond of Mr. J. C. Long of Seaside Farms near Charleston, South Carolina, yielded a harvest from natural recruitment of approximately 50 pounds per acre when it was drained late in the summer of 1950.

Just how many shrimp can live in an acre pond is of great importance. The data which are available are far from complete or satisfactory. In one still continuing experiment there were approximately 30,000 small shrimp 2.5 to 3.00 inches long stocked to an acre of surface area, with an average depth of about 2.5 feet, or 30,000 shrimp to approximately 110,000 cu. ft. of water. The small holding ponds for the bait-shrimp industry temporarily often contain much larger numbers of shrimp. The actual holding capacity of a shrimp farm pond has not been worked out.

The maximum yield of shrimp per acre in any one experiment was 134 pounds, heads on, in 100 days from mid-July to mid-October. This is an experiment in which shrimp were stocked and predators were screened out of the pond. Greater yields can be achieved, since the bio-mass production in an acre salt water pond (Lunz, 1956) is known to exceed 400 pounds.

Questions always arise whether the yield could be increased by supplemental feeding of shrimp stocks. An experiment to give concrete information on this was designed and partially carried out in 1957. However, a catastrophic mortality in one of the ponds, the cause of which is not yet definitely known, has caused a delay in answering this question. Up to this 1957 experiment, no feeding experiments were tried, since the pond cultivation of shrimp began at Bears Bluff Laboratories more than 10 years ago.

In tidal shrimp ponds where water is flowed in through a flood gate, predacious fishes such as spot, croaker, black drum and winter trout are apt to enter the pond. The larger size of such predators can be kept out of the pond by screening the intake with quarter-inch mesh hardware cloth. The normal growth of shrimp is faster than that of predacious fishes, so that such fishes as are able to enter the pond through a quarter inch mesh screen ordinarily do not grow sufficiently to consume any quantity of shrimp before the shrimp are harvested. A few experimental "plantings" of shrimp in ponds indicate the effect of predators. In one, in which 600 or more adult predacious fishes were in the pond, the mortality of shrimp during the period of the experiment exceeded 93 per cent. Another in which over 9,000 small predacious fishes were present in the pond showed that 87.8 per cent of the shrimp stocked were not recovered. A paired experiment showed that a pond from which predacious fish had been screened gave almost double the weight return of shrimp over an unscreened pond with predacious fish.

Ducks and otter are known to consume shrimp and fish in the Bears Bluff ponds (see Progress Report No. 30, Bears Bluff Laboratories, December 31, 1956. Reprinted in *Commercial Fisheries Review*, pp. 47-48, Vol. 19, No. 1, Jan. 1957).

In addition to active predators, the presence of other organisms in the ponds might conceivably influence production if these other organisms compete with shrimp for food or living space. No experimental data are available to illustrate this. No marked difference, not accounted for by some other factor, is seen in the production of shrimp in a pond in which oysters are growing and in a pond in which no oysters are growing. Also no marked difference has been noted due to the presence or absence of mullet in the pond, and at times there have been several hundred mullet cultivated in the same pond with shrimp.

Undoubtedly, shrimp can be grown in ponds in conjunction with other crops such as oysters or mullet, but if the ponds are to be put to their maximum shrimp productivity, it would seem best to confine all efforts to shrimp alone.

From the point of view of managing a shrimp farm, unless growth exceeds mortality there can be little profit. A study of the available records at Bears Bluff Laboratories on mortality figures, frankly, gives a rather confused picture. Some records indicate a mortality of only 7.2 per cent over a period of from 94 to 104 days. The maximum mortality occurred in 1957 during the winter months over a period of 86 days. Here 93.2 per cent of the shrimp were lost. Both these mortality figures are extreme. In the case of the 7.2 per cent, great care was taken to insure that only live, healthy shrimp were stocked in the pond. Only

7,103 shrimp were stocked in a one-acre pond. The stocking was done in July, the harvesting in October. On the other extreme, the 93.2 per cent represents an experiment in which the number of adult predacious fishes exceeded 600. The experiment extended through the winter months. Experience has shown that sudden cold snaps, which bring the water temperature down to 40°F rapidly, actually kill shrimp.

That the condition of the stocked shrimp has great bearing on the ultimate mortality is well illustrated by an experiment in which several hundred shrimp, taken at sea in a trawl, were carefully transported to the Laboratory in a tank. The most vigorous specimens were released in a small pond, but two days later a careful count showed 25.5 per cent of these apparently healthy trawl-caught shrimp had died.

In fact, trawl-caught shrimp have not proven very satisfactory in any of the Bears Bluff Laboratories' experiments. Even though a trawl is pulled for a very short period of time and the shrimp are immediately transferred to live tanks, a far greater number of shrimp arrive at the docks dead than when the shrimp are caught in a cast net and shucked, or emptied, directly into the live tanks. Partially this may be due to the very soft muddy bottoms in the vicinity of the laboratory so that even in short trawl hauls the shrimp are smothered in mud.

The side-frame trawl net method of taking shrimp for the live-bait industry in Florida (Woodburn et al., 1957) has not been employed in South Carolina, where the shrimp habitats in inshore waters are entirely different from those in Florida. Experience has shown that in July and August, when the white shrimp normally are abundant in the creeks and marshes of South Carolina, by using a cast net shrimp can be delivered to the ponds for a maximum of $3.00 a thousand.

An attempt was made five years ago to stock the salt water ponds at Bears Bluff with larval shrimp captured in a plankton net. This experiment was a complete failure.

One of the needs of shrimp farming is a simple and economical method of obtaining post-larval and small juvenile shrimp. Of course, the ultimate goal would be the spawning of adults in the ponds with a subsequent good hatch and high survival of larvae.

Experimental evidence shows that three crops of shrimp can be harvested from a single pond in one year. In South Carolina, 100-count white shrimp are available in February. If these are transferred to the pond, they can be harvested in early June. Young white shrimp become available in July for stocking, to be harvested in October or November. In addition, in South Carolina waters, brown shrimp *(P. aztecus),* although not as readily available as white shrimp, can be taken for stocking in April or May, to be harvested toward the last of July or later. Thus, there is a possibility of three stockings of young shrimp a year. However, experience at Bears Bluff clearly indicates that the July to November crop of young white shrimp by far gives the best results, since, for one thing, their growth approaches one inch a month whereas growth during the winter months is considerably less.

The management of shrimp ponds involves considerable engineering. The manner in which the ponds at Bears Bluff Laboratories were constructed has been generally described (Lunz, 1951 and 1956).

A few additional comments in the form of "don'ts" may be helpful: *Don't* construct ponds in areas where the salinity is apt to drop below that in which

juvenile and adult shrimp normally live. *Don't* fear high temperatures. The water temperature in Bears Bluff's experimental ponds has exceeded 100°F at times and yet shrimp survive. *Don't* expect high survival of white shrimp when the temperature suddenly drops below 40°F. *Don't* fail to build large enough flood gates to drain a shrimp pond completely and within a few hours. *Don't* expect galvanized culverts, used as flood gates, to last indefinitely. At Bears Bluff they have lasted only about eight years. *Don't* attempt to harvest shrimp by cast net alone, or by a seine stretched across the mouth of the flood gate. Build a proper harvest trap. *Don't* fear hurricanes. In a properly constructed pond, the crop may be lost but even light dams can be engineered to withstand hurricane tides.

To summarize the experience in cultivating shrimp in ponds in the marshes of South Carolina at Bears Bluff Laboratories, it is evident that the volume of shimp naturally accumulating in such ponds is not sufficiently large to warrant pond construction. However, experiments show that by stocking these ponds with small shrimp and keeping the number of predacious fishes to a minimum, production can be considerably increased. It is obvious that more research is needed to develop better methods of securing young shrimp for stocking. The ultimate goal would be the breeding of shrimp in ponds.

The engineering of marsh ponds is an important feature of shrimp farming.

The cost of construction, maintenance, and operation of a modern trawler is so high that fairly large acreages of marsh ponds could be constructed, maintained, and operated for the same amount of money. If continued research and management studies can produce the volume of shrimp per unit area being produced in the Orient, a shrimp farm comparable in cost to a modern trawler can produce a much greater poundage of shrimp than can the trawler.

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Shrimp Culture in Asia and the Far East: A Preliminary Review

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1. Introduction

This paper deals with the cultivation of shrimp in Asian countries. The term cultivation is accepted for present purposes as comprising a wide range of industrial practices, some of which, though not properly speaking true cultivation, have been included because of relations they have with true cultural practices, and for the information they can furnish on shrimp in captivity.

Anyone setting out to describe a set of fish-cultural practices applied to a particular species, or group of species, must address himself to two major questions. Firstly, how is it possible to cultivate the particular species under consideration and, secondly, why is it desirable to cultivate this species? The first question calls for examination of the biology of the species and of its ecological requirements and for an examination of the ecological characteristics of the habitat offered to the species in the cultural situation. All culture of aquatic organisms is an exploitation of certain ecological circumstances. Either an existing habitat is taken, isolated to some degree, and preserved or perhaps progressively changed in a chosen direction. Or a habitat is created (e.g., by digging a pond). The cultural operations then are an intervention in the ecological complex, intended not only to ensure the continued functioning of that complex but also to achieve some desired qualitative or quantitative change in both its structure and function. In effect, the culturist aims to provide the individual of the cultivated species with the most favorable environment, including the supply of food and other material at the highest possible rate per individual. At the same time he aims to reduce to as low an intensity as possible the effect of factors that might directly or indirectly reduce the numbers of the cultivated species or their life processes. In order to be able to do these things successfully, the culturist must be equipped with accurate information concerning the cultivated species, the characteristics of its normal habitat and the characteristics of the habitat in which cultivation is to take place, and this information must include some information on the response which any one of these will make to the changes he will try to effect in the others.

To understand the practices adopted for the cultivation of shrimp, and to have any prospect of improving on them, it is necessary to summarize what is available of the information of the kind indicated above as being necessary and to analyze how well the cultural practices have been designed to accommodate the requirements indicated by that knowledge.

The second question stated above involves considerations of ecology, economics and dietary inclinations among humans. In speaking here of ecology we refer chiefly to the position of the species in the food chains of the biocoenosis to which it belongs and to its efficiency as a converter of materials into forms suitable for human use. Some organisms grow quickly and feed on inexpensive and readily available foods, others are slow growers and expensive in their tastes. It is clear that in the shrimp we have an organism that grows quickly and

makes use of a food supply that is abundant, little used by other organisms, and relatively cheap to maintain.

The economic aspects relate to the cost of the operations to secure, protect and rear the stock. Finally, consideration must be given to whether shrimp is a kind of food that can be easily sold at a reasonable price.

In the text that follows a preliminary summary has been made of information found in literature relevant to the foregoing considerations. It is planned that this literature search should be continued and that information should be sought from other sources, and it is hoped that a review will eventually be developed that will serve as a useful basis for the planning of future work to extend, as seems eminently desirable, the cultivation of shrimp throughout the world.

Although shrimp are taken in fishing operations in most countries, the actual farming of shrimp is more or less restricted to certain types of brackish water in some of the countries of Asia and the Far East. The culture of shrimp, in the strict sense of the expression, appears to be limited to the Philippines (Delmendo and Rabanal, 1955; Villadolid and Villaluz, 1951), where the young of *Penaeus monodon* (Hall, 1955) are collected, reared, transplanted and grown in ponds; and to a small extent in Formosa (Thomson, 1955) where fry of *Penaeus carinatus* and *Metapenaeus* (or *Penaeopsis*) *monoceros* are caught and reared. However, the catch of shrimp from the extensive tambaks of Indonesia, from the brackish-water ponds of Singapore, Formosa, West Bengal and East Pakistan, is an important part of the total catch from those fisheries; moreover, large-scale trapping of shrimp is conducted in the rice fields of Kerala on the west coast of South India. The practices have a completely empirical basis, but in recent years interest in shrimp culture has increased, both for the application of these empirical methods in countries where the possibility has hitherto been neglected, and for relevant research that might permit improvements in the techniques. It is reported that shrimp culture is being initiated in Ceylon (de Sylva, 1955) whilst in India improved farming of shrimp by transplantation of fry and extension of existing field practices have been proposed (Panikkar and Menon, 1955) and that in Burma, where shrimp crops are gathered by trapping in the tidal creeks connected with flooded rice fields, measures for increasing the catches are contemplated (U, 1955).

2. Identity, Habitat and Bionomics of Cultivated Shrimp

The species of shrimp known to be cultivated in Asian countries are shown in Table 1. Taxonomic details and morphological characters of the species, which are available in systematic works and in the papers cited in the bibliography, are not given here.

The habitat and bionomics of the major cultivated shrimp are briefly indicated in Table 2. The other species listed in Table 1, with the exception of the freshwater species of Palaemon, also inhabit the sea early in the larval and late in the breeding stages of their life, while they feed and grow to a considerable extent in brackish waters. The range of salinity within which they thrive varies among the species. *Leander styliferus* is predominantly marine, tolerating low salinities, but rarely freshwater conditions. The species of Palaemon can easily accommodate themselves to brackish water from their natural habitat of freshwater but thrive better in the latter.

Shrimp feed by browsing on the substratum or nibbling at the undergrowth and organic detritus. They often act as scavengers, but many of them are car-

TABLE 1

SPECIES UTILIZED IN SHRIMP CULTURE IN ASIA AND THE FAR EAST‡

Scientific name	Common names in various countries	Countries where cultured	Importance in culture	Reference
1. *Caridina gracilirostris* (De Man)	"Chemmeen" (Kerala, India)	India Singapore	Appear in negligible quantities in Kerala fields; listed among shrimp trapped in Singapore	1, 2
2. Eucyphid shrimps		Indonesia	Breed and grow in freshwater ponds in the interior, but available only in small quantities	3
3. *Leander styliferus* Milne-Edwards	"Chemmeen" (Kerala); "Ghora chingri" (West Bengal and E. Pakistan); "Roshna" (W. Bengal)	India	Met with only in negligible numbers in Kerala fields; occurs in brackish-water ponds in West Bengal	2, 4
4. *Metapenaeus dobsoni* Miers*	"Chemmeen" (Kerala)	India	Trapped on large scale in rice fields	2, 5
5. *Metapenaeus* (or *Penaeopsis) monoceros* (Fabricius)*	"Chemmeen" (Kerala); "Kucho chingri" (East Pakistan); "Kiddi" (West Pakistan)	India Formosa Indonesia	Appears in appreciable quantities in rice fields in Kerala. Fry caught and reared in ponds in Formosa. Second in importance among tambak shrimp in Indonesia	2, 3, 6
6. *Palaemon carcinus* Fabricius	"Udang watang"	Indonesia Singapore	A large freshwater shrimp; fetches a good price; listed among shrimp trapped in Singapore ponds	1
7. *Palaemon rudis* Heller		India	Appear in small numbers in Kerala fields	2
8. *Penaeus brevicornis* (Milne-Edwards)	"Yellow prawn"	Indonesia	Ranks third in importance among tambak shrimp	3

TABLE 1 (cont'd.)

Scientific name	Common name in various countries	Countries where cultured	Importance in culture	Reference
9. *Penaeus canaliculatus* Olivier	"Hipon suahe" (Philip.) "Jiaro" (W. Pakistan)	Philippines	Comprises a large portion of shrimp trapped from Philippine shrimp farms	7
10. *Penaeus carinatus* Dana	"Chemmeen" (Kerala); "Giant (black) tiger prawn" (Australia)	Formosa, India	Cultured in Formosa. Occur in negligible quantities in Kerala fields	2, 6
11. *Penaeus indicus* Milne Edwards	"Chemmeen" (Kerala); "Chapda chingri" (East Pakistan); "Hipon puti" (Phil.); "Jiaro" (W. Pak.); "Indian prawn" (Australia)	India, Philippines, E. Pakistan	Frequent in Kerala rice fields; sometimes in ponds in East Pakistan; rarely in Philippine farms	2, 7
12. *Penaeus indicus longirostris* (De Man)*	"Udang puti tambak" (Java, Indonesia)	Indonesia, Singapore	Most important tambak shrimp; listed among trapped shrimp in Singapore ponds	1, 3, 8
13. *Penaeus japonicus* Bate		Japan	Reared in ponds; fed on silk-worm pupae	9, 10, 11, 12, 14
14. *Penaeus monodon* Fabricius*	"Sugpo"; "Jumbo tiger shrimp" (Philippines)	Philippines	Cultivated on large scale, pure and mixed	7, 13
15. *Penaeus semisulcatus* (De Haan)	"Bagda chingri" (W. Bengal)	Indonesia, India	Largest tambak shrimp, but occurs in small numbers; reared in embanked brackish water in W. Bengal	3, 8, 15

‡The list is in alphabetical order for convenience of reference, and it does not indicate the order of importance in culture. Items marked with an asterisk are among the most important in culture.

1. Kow, 1955
2. Menon, 1955
3. Schuster, 1952
4. Kajiyama, 1935
5. Gopinath, 1955
6. Hora, 1955
7. Delmendo and Rabanal, 1955
8. Djajadiredja and Sachlan, 1955
9. Hudinaga, 1935
10. Hudinaga, 1942
11. Kajiyama, 1933
12. Kajiyama, 1935a
13. Villadolid and Villaluz, 1951
14. Seno, 1910
15. Pillay, 1954

TABLE 2

HABITAT AND BIONOMICS OF THE IMPORTANT SPECIES OF CULTIVATED SHRIMP

Species	Salinity range	Preferred habitat	Spawning and fecundity	Food	Longevity and growth records
1. *Metapenaeus dobsoni*	Ranges between sea water and brackish water of varying salinities	Larvae appear in shallow inshore waters of the sea. When about 15 mm long, the young migrate with tidal assistance to coastal estuaries and backwaters. When about to spawn they return to the sea. Males, however, mature in brackish water.	Breeds in the sea all the year round with peak from August to January. Impregnation occurs when females are 65 mm long. When inshore waters are turbid on account of rain or inland discharge, the majority of eggs seem to perish without hatching or the nauplii die soon after hatching.	Foraminiferans, nematodes, copepods, amphipods, cladophorans and species of diatoms *Fragilaria, Coscinodiscus, Pleurosigma, Navicula* and *Cyclotella.*	Life span about 3 years; grows to 114 mm (4.5 inches) (1).
2. *Metapenaeus* (or *Penaeopsis) monoceros*	Very euryhaline, thriving in sea, brackish and fresh waters	Sea for breeding and brackish waters for growth (2)	Observed to spawn from late July to early September in Japan (3)		Life span about one year; grows to 12.7 cm (5 inches)

TABLE 2 (Continued)

Species	Salinity range	Preferred habitat	Spawning and fecundity	Food	Longevity and growth records
3. *Penaeus indicus longirostris*	sea and brackish waters	Larvae appear in sea. When 5 mm long the fry move into brackish water. Adults return to sea before attaining sexual maturity (4).	Spawn in sea		Grows to 203 mm (8 inches) in ponds (5).
4. *Penaeus monodon*	Ranges from sea through brackish to fresh water	Larvae appear in sea. Fry move up to brackish waters where they thrive better than in fresh water. Half year old adolescents get back to shallow sea for spawning	Spawn in sea	Organic detritus, filamentous blue green algae, diatoms epiphyton, small crustaceans and fish and dead and decaying fragments of larger organisms. In farm pond it is given rice bran and meat of oyster and sardine.	Grows to 25 cm (9.8 inches)

1. Panikkar, 1955
2. Menon, 1952
3. Kubo, 1955
4. Djajadiredja and Sachlan, 1955
5. Schuster, 1952

nivorous, and several species prey upon microscopic algae and larvae of larger organisms. Analyses of the food contents of 350 specimens of *Leander styliferus* from West Bengal revealed about 22 per cent by volume of sand grains, obviously swallowed accidentally along with detritus, 38 per cent debris, 10 per cent decapods, six per cent copepods, two per cent mysids, eight per cent other crustaceans, six per cent fish larvae, three per cent insects, one per cent algae, two per cent higher plants and the rest of miscellaneous items like fragments of shells and spicules (Kunju, 1955). *P. japonicus* reared in Japanese ponds have thrived on silk-worm pupae.

Other food such as dried and fermented water hyacinth *(Eichhornia crassipes),* rice straw and "digman" *(Najas* sp. *Ruppia* sp.) and the seaweed "Gulam dagat" *(Gracilaria confervoides)* which are often supplied in milkfish *(Chanos)* ponds primarily for the fish, are also believed to provide nourishment to shrimp.

It would thus be seen that shrimp play an important role in the food cycle of the aquatic biomass, converting into shrimp meat the living, dead and decaying phyto- and zooplankton including microbenthos, epiphyton and fragments of the carcasses of larger organisms. Thus they occupy a place intermediate between herbivores and first-stage carnivores in the secondary stage of biological production. The farming of such a group of animals in tidal areas would involve little expense on the item of feeding, since the rich autochthonous biota in the coastal ponds can easily be supplemented by the wealth of plankton and organic detritus brought in by the tidal inflow.

Regarding growth, the maximum size recorded to be obtained by *P. carinatus* is about 27.5 cm (1.1 inches), *P. indicus* 22.5 cm (8.9 inches), *P. japonicus* 21.6 cm (8.5 inches), *P. carcinus* 30 cm (11.8 inches), and *L. styliferus* 11 cm (4.3 inches).

Shrimp in the countries considered here are preyed upon by several carnivorous fish such as *Lates calcarifer, Megalops cyprinoides, Elops hawaiiensis, Synbranchus bengalensis, Muraenesox cinereus, Glossogobius giuris, Periophthalmus schlosseri* and *Taenioides gracilis,* water snakes and crocodiles. Bopyrid parasites, sometimes found in the gill chambers of shrimp, are believed to inhabit growth and sexual maturity (Kunju, 1955).

3. Extent and Ecology of Shrimp Habitat

Apart from the marine shrimp grounds, where the cultivatable species are found and the extent of which remains still to be surveyed in the seas of Asia, tentative estimates of the brackish-water estuaries, backwaters and lagoons, swamps and coastal lakes in some of the countries are available. In the Philippines there are, according to a 1951 estimate, 880,000 ha (2,175,000 acres) of such areas; in India there are about 518,000 ha (1,280,000 acres); and in Indonesia the coastal tambaks, which are enclosed brackish waters, measure about 129,000 ha (319,000 acres); in Burma, Thailand and Pakistan also there are similar areas.

The brackish-water zone used for shrimp culture is a depositing shore, a description of whose physiography and geological dynamics is given by Kuenen (1950) and, before him, by Johnson (1919).

The biota of this zone (or marine littoral, muddy-bottom biome-type) is discussed in the now classical texts of Ekman (1953) and of Hesse, Allee and Schmidt (1951).

These works permit a general conception of the area in which shrimp culture is practiced. In his work on the brackish-water ponds of Java, Schuster (1952)

gives a good account of the cultivation area, describing its soil, water supply and biota. This account, which derives from Schuster's own field work and from the publications of Delsman, Hardenberg, Sunier (1922) and others, is of particular interest in the present connection because it was prepared expressly for the purpose of presenting the ecological bases on which the Javanese chanos-culture is established.

The fascies presented in the Philippine situation may be understood in their general features, but not their detail, from the preceding references. In contrast, the Indian situation, on the Malabar coast, differs from these others with respect to physiography, edaphic features, hydrological regime and undoubtedly also to biota. The massive account of Chilka Lake in the Indian Museum Memoirs is of considerable relevance to this.

4. The shrimp farms: their size, layout, ecology, etc.

At the risk of being repetitious, it must be emphasized that shrimp cultivation, identified by strict definition of cultural practices, is not extensive and probably exists only in the Philippines, and even there some rearing of fish generally takes place along with growing of shrimps. However, important shrimp production is obtained from quasi-culture, of which there are two kinds. Firstly, there is the practice of trapping and rearing of shrimps in bunded areas in Singapore but also in some other areas. This practice is directed very largely if not quite exclusively upon shrimp, but there are no measures for care of stock or habitat once the trapping has been accomplished. In contrast with this is the second type, found in both Indonesia and the Philippines, where shrimp enter the ponds almost adventitiously and are subsidiary in importance to Chanos and other fish, but where the care of the habitat and the principal stock bears upon the shrimp stock too.

In consequence of these differences superimposed on the differences of the natural situation, it is necessary to consider each of these kinds of ponds separately.

The Philippine Sugpo farms

The following description applies to the layout adopted by some progressive fish farmers in the Philippines (Delmendo and Rabanal, 1955):

A ten-hectare (24.7 acres) swamp in a tidal flat is enclosed by strong primary dykes to keep out tidal waters and upland freshets. At the middle of the dyke adjoining the tidal stream, a main sluice gate of masonry with a water regulator is provided. A secondary dyke, in line with the main sluice gate, bisects the area.

The dykes, both primary and secondary, are built high to be about half a metre (19.7 inches) above the level of the highest tide and floods. The slope of the side is generally 1:1. The crown of the primary dyke ranges in width from one to three m (3.3 to 9.8 feet) according to the nature of the soil, force of the tidal flow, etc.; that of the secondary one ranges from one half to two m (19.7 to 78.8 inches). When the area is bounded by high and dry land on one or two sides, those sides may need partial or no dyking.

Each half of the farm is partitioned off into

(i) a head pond or catch chamber which, together with its opposite chamber, can communicate with the tidal stream through the main sluice,

(ii) a rearing pond communicating with the head pond by a secondary sluice and,

(iii) a nursery connected with the head pond by a water-control system.

The whole area is so levelled that the bottom slopes gradually towards the head pond and to the main sluice. In each pond a system of shallow canals, running from the periphery towards the sluice, further facilitates drainage and harvesting.

Substratum and material of construction.—The soil in the shrimp farm is generally loamy. Besides clay and sand, there is in the farm substratum a considerable amount of organic detritus either brought in by the incoming tide or resulting from the decay of stubble and other organic waste within the farm.

The material for the dykes is generally dug up from the area itself. In the submerged rice fields of Kerala, dykes are constructed by driving in stakes in two rows at the required width, covering the sides with coconut leaf mats, bamboo mats or wooden planks and filling in with mud, often including water grass and twigs of plants. The dykes are often reinforced with laterite stones or rubble. The sides are sometimes lined with rubble with cement pointing. In the sluices, wood of palm or other kind is used for the frame and buttresses; planks are used for the flow regulator and bamboo for the close-mesh screen, which is sometimes augmented with abaco cloth (sinamay). In some cases the sluice gate is made of cement.

The size of the sluice would depend upon the dimensions of the pond. In Kerala the sluice is generally of the box type. The main sluice is as wide as about one to two m (3.3 to 6.6 feet), as long as the width of the base of the dyke, and about one m higher than the dyke. At the crown of the dyke, the ends of the sluice box project on either side. Frequently, the sides and bottom only of the box are planked, the top being just an open frame. At the middle of the sluice there are double grooves, one to carry planks, one on top of another, so that by sliding these the flow can be regulated, and the other groove to receive a close-meshed bamboo screen which is kept in place during the normal flow of water so as to prevent the escape of shrimp.

Water Supply.—The water supply in a shrimp farm is mainly tide-controlled, though sometimes supplemented by rain and freshets. While the depth of water in the farm sections would fluctuate according to the admission of water during high tide and withdrawal during low tide, normally water to a depth of about a metre (3.3 feet) is maintained. Half a metre (1.6 feet) is the minimum in the Indonesian farms.

The salinity varies, depending on the nearness to the sea, extent of freshets and rate of evaporation. It has been observed to range from 29 to 33 parts per thousand in the Kerala shrimp fields where the water temperature is about 35°C during the season. Lower salinities reduce shrimp yield.

Biota.—A variety of biota both autochthonous and non-autochthonous (brought in by the inflow) inhabits the pond water.

i. *Fish and Crustacea.*—These may be raised with the shrimp, either in large numbers as the primary crop, (*e.g.* chanos in Indonesia and the Philippines) and/or in small numbers gaining entry incidentally with the inflow, *e.g.* miscellaneous fish such as milkfish, mullets, pearlspot, etc. in the shrimp fields of Kerala, catfish, eels, and perches, clupeoids, gobies, etc. in the tambaks of Indonesia, small estuarine fish in the mangrove ponds of Singapore, and crabs, lobsters and shellfish occurring generally in such environment.

ii. *Microbenthos.*—The crust on the bottom, known as "tai air" in Indonesia

and "lab lab" in the Philippines, is often cultivated artificially to provide food for shrimp and chanos fry. It consists of a thin, slimy feltwork of filamentous blue-green algae, with bacteria, diatoms, protozoans, rotifers, copepods, ostracods, worms and larvae of crustaceans, mollusks and insects held in it. Patches of "tai air" are sometimes brought up by bubbles of oxygen resulting from photosynthesis, and fragments are frequently torn up and carried about in the higher layers by wind and wave action and other mechanical disturbances.

iii. *Macroflora.*—Algae such as *Enteromorpha, Chaetomorpha* and *Cladophora* float in the water for the greater part of their life. Their earliest stages are attached to the substratum, and their spores often occur in the plankton. *Ulva* has been reported from Philippine ponds. *Spirogyra* sp. and *Oedogonium* sp. have been observed in Indonesia when salinity is low. The higher plants of the ponds include *Halophila, Ruppia* and *Najas*. These plants provide the substratum for epiphytic algae such as chlorophycea and diatoms and tiny animals such as ostracods and insect larvae. Marginal plants, mostly emergent grasses, harbor periphytic algae and other organisms.

iv. *Plankton.*—The great range of variation in salinity, turbidity and temperature, in part attributable to the frequent addition of water by incoming tide and rainfall and loss through discharge and drainage, is the principal cause of considerable variation in the composition and abundance of the pond plankton.

The plankton in the shrimp farms usually consists of hyphalmyroplankton freely brought in by the tidal brackish water and tychoplanktic organisms with some stray items from the neritic plankton of the coastal sea and from the limnoplankton of adjoining freshwaters. Several of the truly marine and freshwater plankters entering the farm die in the confined brackish water, and even then they may serve as food for the shrimp. The number of autochthonous planktonic species which thrive in the farm being limited, they form quantitatively large populations in the absence of too many competitive species.

What has been stated above regarding the Supgo pond would apply in general to the chanos farms in the Philippines in which shrimp is cultured concurrently with fish.

The ecological features of the "tambaks" in Indonesia, where shrimp are raised concurrently with chanos and other fish, have been described in detail by Schuster (1952).

In Singapore, a large part of the mangrove area along the coast has been converted into brackish-water ponds by the construction of dykes. An estimate for 1952 (Kesteven and Burdon 1952) indicates the presence of 68 shrimp ponds covering 265 ha (655 acres) and ranging in size from 0.5 to 30 ha in area. The dykes are about 0.6 to 0.1 m (23.6 to 3.9 inches) wide at the top and are about 0.5 m (19.7 inches) above high water at full spring tide. Each pond is provided with a sluice through which there is communication with the tidal water outside.

In India, the coastal rice fields in Kerala employed for systematic trapping of shrimp amount to about 5,000 ha (12,350 acres). These fields are small holdings, each about a hectare or two (2.5 or 5 acres), but such fields may be leased together to form a "block" of shrimp fields which in some cases may cover about 400 ha (990 acres). These fields are generally classified into three types: (a) fields adjacent to the backwaters and with the maximum tidal influence and hence most productive; (b) those away from the backwaters but connected with

the latter by main brackish-water creeks and canals and therefore of medium productivity; and (c) those farther away and only indirectly connected with the backwaters by minor canals which carry the tidal effect and therefore least productive.

The topographical features of the Kerala shrimp farms have been described in fair detail by Gopinath (1955).

5. Farming Techniques

Even in the areas (Philippine and Formosa) where genuine shrimp culture is practiced, it is rather limited, the general practice being the culture of shrimp concurrently with fish. Concurrent culture prevails extensively in the tambaks of Indonesia and to a limited extent in the embanked brackish-water (Bheris) in West Bengal and Pakistan. But in these three regions, no special nursery operations are involved, the young shrimp merely entering the ponds with tidal water, growing with the fish and being harvested with the latter. What takes place in the rice fields of Kerala and in Burma is only a form of trapping of the wild crop, no special arrangements being provided for the growth of the crop.

5.1 Culture

Fry Collection and Distribution

In the Philippines, the Sugpo fry season extends from May to October, with the peak in August-September. During these months Sugpo fry appear sparsely distributed in the brackish-water areas such as the tidal creeks in the Manila Bay region. Even at the peak of the season, the fry occur only scattered and in small numbers and never in big swarms. The supply of fry fluctuates from year to year.

The fry of this shrimp have straight firm bodies, about 1.5 cm (.59 inches) in length and are easily mistaken for pieces of stick. The coloration which is blackish, with a light brown median streak on the back and alternating black and white bars on the feelers, fades as the fry grow.

Sugpo fry, which have a clinging habit, are usually collected by means of lure lines called "bon bon." Tufts of the grass-like water weed *Paspalum vaginatum* are tied into loops about 25 cm (9.8 inches) in diameter, and these are attached to a long line of string, rattan or wire. The line is laid on the surface of the water and is held in position by being tied to wooden or bamboo poles fixed vertically in the tidal stream at intervals of about 15 metres (49.2 feet).

Several lines may be laid in an area provided they do not obstruct the passage of small craft.

Epiphytic food organisms collecting on the weed loops of the lures attract Sugpo fry which then cling to them. The fry are collected two or three times a day regardless of the weather and tide conditions and sometimes during the night with the help of a lamp or a flashlight, the collector moving about in a small wooden dugout called a "banca."

A small dip net of fine mesh is scooped below the individual loop, and as the net and the lure line at the point of attachment of the loop are gently raised, the loop is shaken to liberate the clinging fry. They are scooped up from the net in a white porcelain bowl and deposited in an eathenware jar. During the collection the fry are sorted and any extraneous species that may appear are discarded. A few dry twigs that have no objectionable sap are

placed inside the jar to enable the fry to cling and also to prevent their escape even if the water should spill. The earthenware jar, being porous, keeps the water cool.

The number of fry obtained from a weed loop at a time may be as many as ten and a collector may gather from 100 to 1,500 fry a day.

In some areas, Sugpo fry left by the receding tide in waters a few inches deep are also collected directly by means of a porcelain bowl, but this is a laborious process, especially if the water is turbid.

The fry are finally distributed in earthenware containers and sold to pond owners.

In Formosa, fry of *Penaeus carinatus* are collected from the sea by scooping them up with a triangular dip net from among bunches of sea weeds deliberately planted for that purpose in shallow bays or inlets at intervals of about 3.5 m (11.5 feet). Often, fry of chanos and mullet are also gathered thus along with the shrimp. Fry of *Metapenaeus* (or *Penaeopsis*) *monoceros* are caught in drag nets drawn along the bottom for catching chanos.

Rearing Fry

Stocking of fry in nurseries.—In the Philippines, Sugpo fry are stocked either exclusively or mixed with chanos. In the latter case the chanos are planted earlier to avoid predation by sugpo. Some farmers stock the shrimp fry in chanos nurseries without any preparation. But better results are obtained when the nursery is prepared beforehand.

The pond is drained, cleaned, levelled and dried. This takes a month or less if the sun is bright. All predators are thus removed. The bottom slopes very gently towards an exit gate made of wood, about half a metre (1.6 feet) in width and provided with a water regulator and a screen. Sometimes a shallow drain is dug from the gate area to the opposite corners of the nursery to facilitate withdrawal of the juveniles as the water level is reduced (Rabanal, Montalban, and Villaluz, 1951). A good "pasture crop" of "lab lab" is deliberately established in the following way: Tidal water is admitted into the dried, levelled pond to a depth of 3 to 10 cm (1.2 to 3.9 inches) through the screen which is supplemented by "abaca" cloth to prevent the entry of predatory species. Water which is too fresh or too salty or turbid is avoided since "lab lab" will not develop well in such water.

The level is maintained for about three weeks by addition of tidal water through the screen as necessary. A natural crop of "lab lab" will appear by that time. The water is now renewed to a depth of about 30 cm (11.8 inches), and the nursery is ready for stocking.

Up to about 500,000 sugpo can be stocked per hectare. The stocking is done during the cooler part of the day, the water in the jar containing the fry is gradually replaced by the water of the pond to be stocked and then the contents are introduced into the pond.

Nursery Upkeep

This is limited to occasional renewal of water whereby additional plankton and detritus are admitted, maintenance of "lab lab" growth and sometimes artificial feeding with rice bran. Overgrowths of branching green algae called "lumut" are kept down since the fry would otherwise become completely en-

tangled and perish. However, the adult sugpo can feed by nibbling on the epiphyton found on "lumut." In about six weeks, with proper care and sufficient food, the sugpo fry will attain a length of about six cm (2.4 inches), a body depth of about one cm (.4 inches), and a weight of about four g (.14 ounces); and at this stage the juvenile sugpo are ready for transplantation into rearing ponds.

Transplantation of Juveniles into Rearing Ponds

Unlike the fry, the juvenile sugpo do not exhibit the clinging habit but burrow in the soft ooze at the bottom, and therefore transplantation is effected in one or other of three ways:

1. Trapping

The juveniles are trapped in one or other type of the widely used bamboo screen traps described above. The traps used for catching juveniles are close meshed, being made of very slender bamboo splinters. Because of the non-gregarious nature and the burrowing habit of juvenile sugpo, only a fraction of the juveniles are obtained in the traps.

2. Capture by Hand

Total capture is attempted by slowly draining the nursery so that the juveniles collect in the shallow channels or deeper areas. From these concentrations, they are easily gathered by hand into pots and finally transferred to the adjacent rearing ponds, regardless of the time of the day, the juveniles being more robust and hardier than the fry.

3. Direct Draining

In some areas where the rearing pond adjoins the nursery, the juveniles are admitted directly into the rearing pond by cutting away a part of the partition dyke and draining the nursery straight into the rearing pond, the former being shallower than the latter.

In stocking the young shrimp regularly cultured as outlined above, about 10,000 juvenile shrimp per ha are stocked in rearing ponds along with chanos since the two have been found to be compatible.

Care of Stock

Before stocking the rearing pond with juveniles, the former is usually drained, cleaned, dried and supplied with screened water to a depth of half to one metre (1.6 feet). Often, algae collectively called "lumut" is planted in the pond to serve as food to the chanos and to provide epiphyton for the sugpo to nibble.

In the Philippines very little special attention is paid to the sugpo in the rearing ponds other than the usual care of the fish pond and periodic renewal of water, the water being admitted at high tide and let out at low tide. The sluice is screened during the flow of water so that predators are kept out and the shrimp are prevented from escaping. However, abundant planktonic food organisms can enter the pond through the screen during the renewal of water. Besides the food organisms which grow in the pond and which are brought in during the renewal of water, the sugpo also consume the artificial feed supplied to milkfish. The sugpo attain in about six months a marketable size of about 15 cm (5.9 inches) in length, two cm (.8 inches) in depth, and 20 g (.7 ounces) in

weight. However, only a proportion of the stock is caught at this stage. During the subsequent months a few of the growing sugpo are caught occasionally. Those which are left till the end of the year attain a length of about 25 cm (9.8 inches), a depth of about three cm (1.2 inches), and a weight of 100 g (3.5 ounces).

Harvesting

The Philippine sugpo being non-gregarious and burrowing in habit, are not easy to catch and none of the methods employed seems to ensure complete harvest.

i. *Bamboo screen traps.*—Different kinds of traps are made of bamboo screen, consisting essentially of slender bamboo splinters held together in series by intertwining cords near the upper and lower margins and at regular intervals between them. The height of the screen rises about half a metre (1.6 feet) above the water level where it is used. The length can be adjusted by the addition of pieces of screen as required. The screen itself is termed variously in different areas, e.g., "Baklad" (Philippines) (Clifford, 1955); "Adichil," "Thaithal" (Kerala) (Venkataraman, 1955). The traps themselves are called by different names according to the pattern and place of origin.

(a) "Bakikong."—This consists of a guiding wall fixed vertically at right angles to the dyke, starting from the latter and leading into an ante-chamber which has a catch-chamber at the cod end.

As the shrimp move about, they strike upon the guiding wall and are led to the ante-chamber and then into the catch-chamber where they concentrate and are collected periodically with a dip net.

(b) "Aguila."—This is but a modified Bakikong and consists of a long leader guiding to a pair of strategically located chambers in which the shrimp collect.

(c) "Paabang."—This trap has two wings leading to a central posterior chamber. It is fixed in a narrow gap made in the dyke so that during a strong outflow of water the shrimp are collected in the catch-chamber.

ii. *Net Trap.*—Locally called the "lumput," this is essentially a bag net of coarse cotton twine mounted on a wooden frame which can be fitted into the screen grooves of the sluice gate. The bag tapers to an open cod end tied shut with string. The pond is filled to its maximum level at the high tide, and when the tide has gone down to the lowest level the sluice is opened with the net trap laid in position. As the water rushes out, the current carries the shrimp to the cod end of the bag from where they are gathered.

Sometimes when the farm is drained out, sugpo are also caught by hand.

Stocking and rearing of wild populations

In the brackish water ponds in most of the countries under consideration, some young stages of shrimp enter the fish ponds accidentally through the sluices and grow and are ultimately caught along with the fish. As instances of deliberate stocking of young shrimp for concomitant culture with fish may be mentioned the operations in Indonesia and the Philippines where shrimp are admitted along with the tidal water periodically introduced into the chanos ponds and in West Bengal, East Pakistan and Singapore where they are let into the "Bheries" or brackish-water farms and mangrove ponds with young stages of coastal

species of fish (Kunju, 1955; U ba Kyaw 1955). The shrimp grow along with the fish, and they are caught every now and then by traps set in the ponds or at the sluices.

Trapping of adolescent Stages

This is the major practice prevalent in the extensive rice fields in coastal areas of Central Kerala in South India (Menon, 1955; Gopinath, 1955; Panikkar, 1955). Although a quarter of a century ago, actual culture by rearing young shrimp for two to three months used to be in vogue there, especially around Narakal, the current practice aims only at trapping the shrimp in the field with the incoming tide after the annual single crop cultivation of rice and fishing them during the favorable low tide.

During the period of rice cultivation from June to October the backwaters which connect with these fields are flooded after the south-west monsoon rains, and the water both in the rice fields and in the adjoining backwaters is practically fresh, except where the latter joins the sea. By October when the rice harvest is over and the north-east monsoon commences, this rainfall causes a second flooding and the rice fields become submerged and confluent with the backwaters and canals.

By November this flood subsides and with the reduction of freshwater flow, the water begins to turn brackish until the salinity reaches the maximum of about 32 per mille or more in March-April.

Preparations for shrimp farming usually start in November. Blocks of fields are taken on lease for about five months from the owners of the small individual fields. The dykes are strengthened and sluices installed. When the high tide is at its maximum in the adjoining backwater or creek, the sluice is opened so that the tidal water flows in forcibly carrying with it adolescent shrimp.

Often a lamp is hung at night near the sluice to attract the shrimp to the area. When the level in the field has risen to the same height as the water outside, which may take half an hour, the sluice is closed. When the tide has fallen to lowest ebb outside, the regulator of the sluice is opened after fixing a bag net at the opening. The net is about 7.5 m (24.6 feet) long, with a mouth about 1.8 m (5.9 feet) square and the opening of the cod end about 0.3 m (.98 feet) square. It has ten sections, the one at the cod end having a mesh of 3.2 mm (.13 inch) the next seven sections with a 6.4 mm (.26 inch) mesh and the ninth and tenth sections with 12.7 mm (.5 inch) mesh. In smaller fields, nets of smaller dimensions are used. A large portion of the water is thus let out and a considerable proportion of the shrimp which had gained entry into the field with the high tide is now caught in the bag net. At the next high tide, water and shrimp are again admitted. By repeating the process, a catch is obtained during the discharge at every low tide. Nevertheless, a residual crop of shrimp remains in the field, and this may be collected only when the field is completely drained and harvested at the end of the season.

Some farmers continue to admit the shrimp at high tide on successive days, screening the sluice during the discharge and thus allowing them to accumulate and grow for a few days before capture. The process is repeated several times during the season. In all these cases, very little attention to the stock is called for, although during the interval of a few hours or days that the trapped shrimp remain in the fields they utilize the food organisms within the field and those brought in by the tidal water.

6. Utilization

Regarded as a delicacy, sugpo is the most highly prized shrimp in the Philippines. Apart from the subsistence fishing that prevails, the sugpo being in high demand locally, they are mostly sold fresh, and only a very small fraction is sometimes boiled, salted and dried, shelled, further dried and marketed as "hebe" (Domantay, 1955). The tambak shrimp of Indonesia also is largely sold fresh, a part being preserved as different kinds of dried shrimp called "ebi," "bekasem udang" and "dengend udang." They may also be converted into crackers termed "Krupuk" and "Remejek" which resemble potato chips but inflate up into crisp puffs when fried. In Kerala, the bulk of the catches obtained from the shrimp fields is sun-dried or boiled in fresh or salt water, dried, shelled by threshing them in guny bags and packed for export particularly to Burma. A small quantity is sold fresh locally or iced and distributed to inland markets by rail. Sometimes the boiled and shelled shrimp is pickled in vinegar or fermented palm juice with condiments and spices (Chacko, 1944; Venkataraman, 1955). The shell and dust resulting from shrimp curing is used to a small extent as livestock feed but largely as fertilizer.

7. General observations and discussion

The economic status of shrimp culture varies from place to place according to the extent and type of cultural activity, the species raised and the social pattern of the shrimp farmers. In the Philippines, sugpo culture has become a lucrative undertaking in the regions neighboring the fry grounds. The sugpo fry grounds are open and free waters unlike the chanos fry collection grounds which are leased out. This is partly because the sugpo fry industry is not as well developed as the chanos fry trade and partly on account of the scattered and sparse nature of the sugpo fry populations. However, in the towns bordering the Bacoor Cove, sugpo fry industry by itself provides a source of livelihood for many. The fry are sold at anything from 1.5 to 6 pesos* per hundred. Owners of chanos and other brackish-water fish farms find in shrimp culture a supplementary source of income.

The rate of production varies greatly from place to place. Up to 500 kg (1100 pounds) of *P. monodon* per ha (2.47 acres) (500 pounds per acre) is estimated to be obtained per crop in the Philippine ponds, usually one crop being raised a year but sometimes two a year or three in two years. Even from the wild stock of shrimp entering the estuarine fish ponds, a yield of 50 to 200 kg (110 to 440 pounds) per ha (2.47 acres) is obtained. In Indonesia, 3,300 tons of shrimp are obtained annually from the 93,000 ha (230,000 acres) of ponds in Java and Madura. In Java, about 900 kg (1980 pounds) per ha is the estimated production rate. In the three types of fields in Kerala the production rates per ha are 1,210 kg (2,662 pounds), 706 kg (1,553 pounds) and 403 kg (887 pounds) respectively. In Singapore brackish-water ponds, shrimp production has been estimated to be about 611 kg (1,344 pounds) per ha.

Wherever wild populations of shrimp are used as stocking material, the production depends largely on the quantity of fry entering the pond with the tidal water, though to some extent on the closeness of the farm to the tidal creek or backwater and the nature of the substratum.

The difference in productivity between the three classes of shrimp fields in Kerala is reflected in the leases which the shrimp farmer pays to the owners of

*1 peso = U. S. $0.50

the fields and in the normal fees he pays to the government to conduct his operations. It is significant from the view point of land reclamation that a few years ago about 123 ha (304 acres) of low land close to the sea in Edavanakad near Cochin became subject to sea erosion and thus waterlogged and unsuitable for rice culture. The area has, therefore, been turned into shrimp-trapping fields.

Judging then from the general account of the bionomics of shrimp, it will be seen that although the young generally hatch in the sea, several species of shrimp may be transferred to brackish water ponds of varying salinities where they can utilize the rich supply of living and dead organisms and waste organic substances so characteristic of these rich highly tropic areas. Their short life span permits a fairly quick turnover of the crop, and systematic cultivation can provide some protection against predators.

The mutual repercussions of the marine shrimp stocks and the brackish water shrimp crop with reference to increased sea fishing activity on the one hand and the extension of shrimp culture and trapping in the brackish waters on the other, are problems deserving attention. The possibilities of artificial propagation including the induction of spawning in confined coastal waters and the increase, thereby, of dependable supplies of stocking material need investigation, especially in the case of the sugpo in the Philippines, where the lack of fry is recognized to be the main obstacle in the way of utilization of the extensive chanos ponds for the culture of that shrimp. Apart from the limited observations on growth recorded in the case of a few species—and many of these seem to require verification—the rate of growth, the environment of best growth and the maximum size attained in the case of the various cultivatable species of shrimp also require fuller elucidation before the economics of shrimp farming can be determined and operational improvements in the farming techniques formulated.

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DISCUSSION

Shrimp Session

Discussion Leader: William W. Anderson
Discussion Panel: Austin B. Williams, William R. Neblett, Berlin Felton, Ernest Mitts, Walter O. Sheppard

The Shrimp Resources of Continental Latin America

Milton J. Lindner

Q. Neblett: Do you think there is any possibility that the Brazilian catch of shrimp could become large enough to be exportable?

A. Lindner: Yes. Along the northern coast south of the Amazon there is an area producing five or six million pounds of small shrimp a year. About half of these are seabobs. The other half are white shrimp and brown shrimp. The problem there is whether the area can be trawled successfully. The bottom is muddy and tidal fluctuations are great.

Q. Felton: Do you know the season that shrimp are found on the Honduras coast?

A. Lindner: In Honduras and Nicaragua it is mostly during the spring and summer. Catches here are very sporadic. The same thing is true along the coast of Nicaragua and further south to Bluefields. Occasionally they find them along the beach, mostly in the fall. Some years the shrimp come in along the beaches and other years they do not.

Q. Williams: Are these concentrations of shrimp all adjacent to the nursery grounds?

A. Lindner: Yes. I don't know any place where there is a concentration of shrimp not adjacent to the nursery grounds.

Q. Rae: I am not sure what is implied by a potential catch of a fishery; what factors are taken into consideration?

A. Lindner: I have tried to take into consideration the nursery ground areas and other environmental factors, how much a boat catches in a day or a month, and then I have tried to make a guess as to what the potential might be in that area. It is a wild guess on many occasions.

Q. Allston: Could you tell us something about the Chilean langostinos?

A. Lindner: The langostinos are members of the family Galatheidae. They are found in depths from 40 to 100 fathoms or more. The yield is quite small because they have tremendous heads, considerably larger than the tail. It is called the plated lobster, but it is not a lobster, it is a shrimp.

The trawlers go out in the morning and come back in the evening with their catch, generally in boxes of 40 kilos to a box. They are brought to the plant for cooking and freezing. In the state of Valparaiso, they cook them in salt water, cool them and peel them. They handpack them in trays and then freeze and glaze them in plastic bags. Then they are packed in wooden boxes for shipment.

Q. Strasburger: This year, with the very small catch of shrimp for canning purposes, the canners are trying to obtain supplies from any area which they might find shrimp. Within the past four or five weeks I have had 15 to 18 samples of shrimp from various countries submitted for examination as to their possible use for canning purposes. Most of the samples appeared to be seabobs. Is there a general rise in the seabob fishery by people hoping to ship them into this country?

A. Lindner: I suspect most of your seabobs have been coming from Panama and Ecuador. In 1955 and 1956 fishermen were catching seabobs but were throwing them away. It didn't pay them to bother with sizes smaller than 21-25's. But now, both in Panama and Ecuador, they are peeling the seabobs and some of the other smaller varieties of shrimp for freezing and shipping to the United States. It is a matter of economics: the price has gone up.

The Shrimp Fishery of Panama

RICHARD EISENMAN

Q. Neblett: I gathered that the methods they are using in Panama are far ahead of those of other Latin countries.

A. Lindner: Panama has a large fishery which has been going longer and is further developed than many, but Ecuador, for example, is not much behind Panama. They use more chill tanks in Ecuador than they do in Panama, for example. The vast majority of the boats in Ecuador have chill tanks.

The New Shrimp Fishery of the State of Washington

JOSEPH STERN

Q. Mitts: How many months a year do the boats operate in this fishery?

A. Stevens: It is a year-round fishery.

Q. Neblett: What is the size of these shrimp?

A. Stevens: To people in the Gulf these are very small shrimp, 120 to 150 count, head on.

Q. Felton: Am I correct that the life span of these shrimp is three or four years? This is different from the local shrimp.

A. Stevens: Yes, that is right. This species of shrimp is a male for two years and then becomes female and so will not produce eggs until the third year.

Q. Collins: Would you describe the peeling machine?

A. Stevens: It is the same machine that was developed in New Orleans. It can handle about a thousand pounds per hour. The industry could not operate without such a machine because catches have been phenomenal. I believe that one vessel brought in 35,000 pounds from one trip.

Whiteleather: (Comment) There have been catches up to 3,500 pounds of shrimp per 20 minute tow by the exploratory fishing vessel *John N. Cobb*. The fishermen get seven cents a pound, which is a profitable price for them considering their large catches. There are other concentrations of these same pink shrimp in Alaska which appear to be heavier than those on the Washington coast, especially on the south side of the Aleutian chain.

Research on the Biology of the Tortugas Shrimp

EDWIN S. IVERSEN, C. P. IDYLL, ALFRED VOLPE

Q. Felton: What happens to the tag after the shrimp sheds, and what size shrimp are you tagging?

A. Iversen: We know from our tagging experience that the shrimp can molt successfully with the Peterson-type button tag. We have seen tagged shrimp with a small piece of old shell clinging to the pin. As to size, we are tagging shrimp as

small as hundred count (20 mm. carapace length). If the mortality is high we will have to tag more of these smaller sizes to get reasonable returns.

Q. Williams: What happens to the intestine or to the nervous system when the shrimp sheds the steel pin through the tail? It seems that the pin would injure some of the internal organs when the shrimp molts.

A. Iversen: The pin is put through tail muscle, not through vital organs, and it stays in place through the molt. The shell splits around the pin and no organs are affected.

Q. Galtsoff: Do you consider it feasible to determine the mortality of this population of shrimp?

A. Iversen: First we have to have some information on the amount of movement, especially into non-fishable areas. If shrimp were evenly distributed and were equally available to the boats at all times I think it would not be impossible, but at the moment it seems very difficult to assess mortality with tags.

Fish and Wildlife Service Biological Research on Shrimp

George A. Rounsefell

Q. Rae: Will stained shrimp be easily recognized when they are recaught?

A. Rounsefell: The marking seems to be very plain. There is a green, a red and two blue stains which are successful. The green stain is the best and the clearest. After having been injected into the shrimp, it creates a bright colored spot, which persists for months with little fading.

Pond Cultivation of Shrimp

G. Robert Lunz

Q. McConnel: We from Louisiana are particularly interested in pond culture of shrimp. Can you give me some idea what size the ponds would have to be to be economical?

A. Anderson: Mr. Lunz's ponds are only an acre in extent. The FAO paper this morning spoke of 10 to 20 acre ponds. I would think that something along that order would be sufficient on a first experimental basis.

Galtsoff: (Comment) I believe one important thing should be kept in mind in experiments with pond culture of shrimp. As soon as artificial conditions are created, such as those in ponds or tanks where a large population of life is in confinement, it is unavoidable that we come into difficulties with the problem of epizootics. Any organization studying the cultivation of shrimp in ponds should, from the very beginning, make the problem of epizootics a part of the program.

WEDNESDAY—NOVEMBER 13

Chairman—JOHN MEHOS, *Liberty Fish and Oyster Company, Galveston, Texas*

Some Plant-Scale Applications of Chlortetracycline For Fish Preservation

LIONEL FARBER AND PETER LERKE

Fisheries Research Laboratory, Hooper Foundation, University of California, San Francisco

Introduction

THE AUTHORS PREVIOUSLY have shown (Farber, 1954; Farber and Lerke, 1956; Lerke and Farber, 1956, 1956-57) that the treatment in the laboratory of fillets, of whole fish, and of shrimp with the tetracyclines markedly extended their keeping quality at 42°F or lower. The question then arose as to the efficacy of the antibiotic treatment of fish under the more practical operating conditions existing in the fish plants. The present report presents the results obtained from some storage tests carried out in various fish plants in Monterey and San Francisco, including, in one case, the added effect of truck transportation from Monterey to and from San Pedro.

Experimental

Fish used — Fillets of sole (of various types, including English, Dover, Lemon and Petrale) and of various rockfish species (*Sebastodes* sp.) were taken from the filleting line in the plants for treatment and storage. The whole sole, sand dabs and mixed flat fish, including flounder, were taken from the trawl, which was dragged along the ocean floor, placed in fish boxes and covered with plain or treated crushed ice.

Treatments — The fillets were dipped five minutes in a five per cent salt brine with or without 5 or 10 p.p.m. of chlortetracycline (CTC) pure or as the mixture called Acronize PD. The whole fish on shipboard were placed in plain ice or in ice containing 10 p.p.m. of CTC as Acronize BI. On landing, the fish in the ice were either taken to the fish plant and stored without any further treatment (usually about six to eight hours) until brought to the laboratory, or they were picked up from the fishing vessel and taken directly to the laboratory.

Storage conditions — The fillets were stored in the usual metal shipping boxes in the plant cold storage rooms, where the temperatures ranged from 30° to 35°F. In one case the fillets in the metal boxes were covered with ice in wooden fish boxes and stored at 30°F for a few days before and after being shipped by truck from Monterey to San Pedro and return. The whole fish, after removal from the ice at the laboratory, were examined, judged, and then stored in the fish boxes, under damp sacks to minimize dehydration, at atmospheric temperature ranging from 55° to 60°F.

Laboratory examinations — The fish fillets or in the round were periodically examined organoleptically, chemically for their content of volatile reducing substances (V.R.S.), total volatile and trimethylamine nitrogen (T.V.N. and T.M.N.) and bacteriologically for their aerobic bacterial count, expressed as log of bacterial numbers. The procedures for these tests have been described previously (Lerke and Farber, 1956-57).

Results

An experiment was set up to test the effect on the keeping quality of rockfish fillets (*Sebastodes* sp.) treated with CTC under rather severe practical conditions. The fillets, taken from the filleting line of a Monterey fish plant, were dipped for five minutes in a five per cent salt brine and in a five per cent salt brine containing five p.p.m. of CTC. The two lots of fish were then placed in individual metal fish containers, which were then imbedded in ice in a wooden fish box and stored overnight at 30°F. The next day the boxes were filled with ice, closed and shipped by truck to San Pedro. They arrived there the night before a holiday. As a result, the boxes of fish remained outside the plant for about 36 hours at atmospheric temperature, that is from Wednesday evening July 3 to Friday morning July 5. The boxes were then re-iced, stored at 30°F over the weekend, and Monday morning were sent back by truck to Monterey, where they arrived that evening. They were stored overnight at 30°F and then sent in ice by truck to the laboratory in San Francisco for examination. The results of this test are summarized in Tables 1 and 2.

TABLE 1

STORAGE EXPERIMENT ON ROCKFISH FILLETS

Tues., July 2—Fillets dipped 5 min. in 5% NaCl brine with and without 5 ppm CTC, then placed in metal box which was covered with ice and stored at 30°F in Monterey.

Wed., July 3—Box in ice shipped by truck to San Pedro, where it arrived that evening.

Thurs., July 4—Holiday. Fish left outside of plant.

Fri., July 5—Fish taken into plant, re-iced and stored at 30°F.

Mon., July 8—Box re-iced and shipped by truck to Monterey, arriving that evening. Stored overnight at 30°F.

Tues., July 9—Fish in ice shipped to laboratory in San Francisco.

A storage test in a second fish plant is summarized in Table 3. Fillets of sole, removed from the filleting table, were dipped five minutes in five per cent salt solution and in five per cent salt solution containing 10 p.p.m. of CTC (as Acronize PD). Both lots were then stored in metal fish containers at 30°F in the cold storage room of the plant. Fillets were removed periodically for organoleptic, chemical and bacteriological examinations.

Another test in a third fish plant was carried out on sole fillets removed from the filleting table. They were also dipped for five minutes in a five per cent salt solution and in a five per cent salt solution containing 10 p.p.m. of CTC. The fillets of both lots were then stored in metal fish boxes in the cold room of the plant which was maintained at a rather fluctuating temperature of about 35°F. The fillets had a content of CTC ranging between 0.68 and 1.04 gamma

TABLE 2

STORAGE EXPERIMENT ON ROCKFISH FILLETS

Sample	*VRS*	*mg Volatile N/100 ml Total*	*Trimethylamine*	*Log bacterial numbers*	*Condition*
Original	3.1	0.7	0	4.92	good
Control-after week	55.0	43.5	13.2	9.32	putrid
CTC treated-after week	12.1	6.6	3.9	8.81	V. sl. storage odor, still considered merchantable though not first quality
CTC content of fillets — 0.224 gamma/gram					

per gram, averaging 0.87. The results of this storage test are summarized in Table 4.

Another storage test in the third plant was carried out on fillets of sole. These were treated as those in Table 4. The data obtained in this experiment are shown in Table 5. The CTC content of the fillets ranged from 0.30 to 1.32, averaging 0.70 gamma per gram.

Three experiments were carried out on whole fish on board two different fishing vessels. Table 6 summarizes the findings of the storage test from one of the boats. The fish when removed from the trawl on shipboard were placed in two wooden fish boxes, one containing plain ice and the other containing ice with 10 p.p.m. CTC (made with Acronize BI). The fish were brought ashore in the boxes of ice and taken to the laboratory after about 24 hours

TABLE 3

STORAGE EXPERIMENT ON SOLE FILLETS AT 30°F

Days Stored	*VRS*		*TVN*		*TMN*		*Log Bacteria*		*Remarks*	
	C	*CTC*	*C*	*CTC*	*C*	*CTC*	*C*	*CTC*	*C*	*CTC*
0	9.2		2.1		0		5.06		good	
1	6.2	7.6	1.5	1.5	0	0	4.95	4.75	"	
2	7.0	5.9	1.2	0.9	0	0	5.04	4.67	"	
4	5.4	5.6	2.5	1.5	0	0	5.60	4.58	"	
6	11.9	8.1	5.0	3.7	0.9	0	6.18	4.70	passable	good
8	11.8	10.2	7.8	5.0	3.7	0.6	6.65	4.82	"	"
9.5	15.6	5.4	8.7	5.3	6.8	0	7.72	4.95	stale and slimey	"
11	30.2	7.5	13.8	8.7	7.8	0	8.08	5.48	spoiled	"
13	—	5.9	—	—	—	0	—	5.85	—	"
15	—	5.4	—	5.0	—	0	—	6.18	—	"
17	—	3.8	—	5.6	—	0	—	6.10	—	"
18	—	4.5	—	5.6	—	0	—	6.15	—	"
20	—	9.7	—	7.8	—	1.9	—	8.70	—	passable
23	—	30.8	—	6.3	—	2.5	—	8.48	—	ammoniacal and discolored —not passable

TABLE 4

STORAGE EXPERIMENT ON SOLE FILLETS AT 35°F

Days Stored	*VRS*		*TVN*		*TMN*		*Log Bacteria*		*Condition*	
	Cont.	*CTC*	*C*	*CTC*	*C*	*CTC*	*C*	*CTC*	*C*	*CTC*
0	3.9		2.0		0		5.72		good	
4	6.6	8.3	5.9	5.2	0.3	0	7.18	4.48	good	good
5	39.6	7.4	10.5	3.3	6.6	0	8.85	6.32	spoiled	good
6	—	2.2	—	2.6	—	0	—	6.40	—	"
7	—	3.0	—	3.3	—	0	—	6.96	—	"
8	—	2.6	—	3.3	—	0	—	8.04	—	"
11	—	11.8	—	6.6	—	4.6	—	8.96	—	passable
13	—	8.8	—	8.6	—	3.9	—	9.00	—	passable
15	—	5.9	—	2.6	—	0	—	8.92	—	"
16	—	27.2	—	5.3	—	3.3	—	9.00	—	spoiled

TABLE 5

STORAGE EXPERIMENTS ON SOLE FILLETS

Days Stored at 35°F	*V.R.S. Control*	*CTC*	*TVN C*	*CTC*	*TMN C*	*CTC*	*Log Bacteria C*	*CTC*	*Condition C*	*CTC*
0	1.6		0.9		0		6.08		good	
2	4.9	1.3	1.5	0.6	0	0	6.05	5.91	good	good
5	2.7	2.7	0.9	0.6	0	0	6.36	5.60	good	good
7	6.5	5.9	1.2	0.9	0.3	0	7.73	6.18	"	good
8	13.5	—	4.1	—	0.6	—	7.85	—	near borderline	—
9	40.0	6.6	6.0	0.9	3.1	0	8.79	7.60	spoiled	good
12	—	11.3	—	3.2	—	0.3	—	—	—	passable
13	—	7.5	—	1.2	—	0	—	—	—	good
14	—	15.1	—	6.2	—	1.2	—	—	—	borderline passability
15	—	44.5	—	3.1	—	2.5	—	8.30	—	spoiled

from the time they were caught. They were removed from the ice and stored in the same fish boxes at atmospheric temperature of 55° to 60°F.

The results shown in Tables 7 and 8 were obtained from the same fishing boat on two different occasions. The fish of Table 7 were whole sand dabs (*Citharichthys sordidus*) which had been treated similarly to those of Table 6; that is, they were placed in plain ice and in ice containing 10 p.p.m. CTC on removal from the trawl on shipboard. On arrival at the laboratory before storage at ambient outside temperatures they were between 18 and 24 hours out of the water. The fish of Table 8 were mixed flat fish, consisting of sole, dabs and flounders (*Platichthys stellatus*). They were treated aboard ship as those of Tables 6, 7 and 8. On arrival at the laboratory they were about 24 hours out of the water. They were also removed from the ice and stored at ambient outside temperatures between 55° and 60°F. All the whole fish were filleted and the skinned fillets were then analyzed.

TABLE 6

STORAGE EXPERIMENT ON ROUND SOLE

Hours	V.R.S.		TVN		TMN		Log Bacteria		Remarks	
Stored at 55-60°F.	Plain ice treated	CTC ice treated	Plain ice treated	CTC ice treated	Plain ice treated	CTC ice treated	Plain ice treated	CTC ice treated	Plain ice treated	CTC ice treated
0	3.3	2.2	1.9	0.6	0.6	0	4.66	4.00	good more slimey	good
30	14.2	4.9	5.0	1.2	1.2	0	—	—	borderline	good
48	33.5	6.6	8.2	1.6	2.5	0.3	7.49	5.42	spoiled	good
56	—	7.4	—	4.4	—	0.12	—	6.08		good

TABLE 7

STORAGE EXPERIMENT ON WHOLE SAND DABS

Hours	V.R.S.		TVN		TMN		Log Bacteria		Remarks	
Stored at 55-60°F.	Plain ice treated	CTC ice treated	Plain ice treated	CTC ice treated	Plain ice treated	CTC ice treated	Plain ice treated	CTC ice treated	Plain ice treated	CTC ice treated
0	7.1	6.0	1.9	1.5	0	0	5.86	5.34	fairly good more slimey	good
24	7.1	3.3	4.4	3.4	0.6	0	5.70	3.85	same	same
32	14.6	6.2	7.9	4.2	3.1	0	6.85	6.00	some off odor to fish more slimey & discolored	same
48	47.2	12.1	12.5	6.2	6.9	0.6	7.72	7.45	spoiled	still passable appearance

TABLE 8

STORAGE EXPERIMENT ON ROUND FLAT FISH

Hours	V.R.S.		TVN		TMN		Log Bacteria		Remarks	
Stored at 55-60°F.	Plain ice treated	CTC ice treated	Plain ice treated	CTC ice treated	Plain ice treated	CTC ice treated	Plain ice treated	CTC ice treated	Plain ice treated	CTC ice treated
0	3.8	3.8	3.1	3.1	0	0	5.28	4.74	good more slimey	good
18	18.1	4.4	3.8	2.4	1.9	0	6.98	4.50	some off odor to whole fish, very slimey	good
23	32.9	6.9	6.4	3.4	3.1	0	6.61	5.28	spoiled	good
40	—	3.3	—	2.5	—	0	—	6.83		still passable
48	—	8.7	—	3.1	—	0.9	—	7.60		slight off odor to whole fish

Discussion

The data of Tables 1 and 2 show that even under rather adverse handling conditions a CTC dip prolonged the keeping quality of rockfish fillets by about a week. This probably represents a minimum value, with longer keeping times possible under more favorable storage conditions.

From an examination of the data of Tables 3, 4, and 5 a number of observations can be made.

1. A CTC dip definitely prolongs the storage life of sole fillets.

2. The actual length of the added storage time resulting from the CTC dip depends upon many factors, including, among others, the history of the whole fish from catching to the start of filleting, the sanitation of the filleting operation, and the storage temperature of the fillets. As a possible example of the effect of the original bacterial load on the fillets, on their keeping quality, the data of Tables 3, 4 and 5 may be applicable. In Table 9 are summarized the original bacterial counts of the fillets and the subsequent estimated time in days before any spoilage became evident. It will be seen that for the untreated fillets the original bacterial load did not apparently have too much effect on their keeping quality. For the CTC-treated fillets, on the other hand, there was an apparent increase in keeping time with a decrease in initial bacterial load. The difference in storage temperatures may not have too much effect in this case, since the fish were stored in commercial cold storage rooms in the plants, which were opened many times a day for varying times and the temperatures fluctuated in all cases. Therefore, even though the lower average storage temperature no doubt contributed to the longer keeping time, the differences in bacterial loads very likely also could have had an effect. This also accentuated once more the marked interrelationship between sanitary operating conditions and the beneficial effect of an antibiotic treatment.

3. The content of V.R.S. was found to be a more useful guide to the condition of the fillets than any of the other chemical and bacteriological criteria. In this connection it may be of interest to point out the lack of correlation between the total aerobic bacterial count and the condition of the fillets, as determined either organoleptically or chemically by the V.R.S. content. Total bacterial counts higher than in the spoiled controls were found in CTC-treated fillets which were judged still passable. When methods become available to determine the number of potentially spoilage bacteria their count may correlate better with their condition. This bacteriological problem is at present being investigated in this laboratory.

The experiments on the effect of storage of whole flat bottom fish in plain and CTC-containing ice were of interest. Apparently, the treatment of the whole fish immediately on removal from the water with the antibiotic in the ice must pre-

TABLE 9

CORRELATION BETWEEN ORIGINAL BACTERIAL COUNT OF SOLE FILLETS AND SUBSEQUENT STORAGE TIME BEFORE BEGINNING OF SPOILAGE

Log Initial Bacterial Count	Days before any spoilage evident	
	Control untreated	CTC-dipped
5.06	9	21.5
5.72	4.5	15.5
6.08	7.5	13.5

vent the initial development of the spoilage organisms. As a result, subsequent longer storage periods of the treated whole fish without any ice was possible, compared to fish originally placed in plain ice. The fact that the flat fish have a very small intestinal tract area, compared to the total area of the fish, also must have added a favorable influence on the storage periods. Other experiments carried out on small round fish, such as herring and sardines, which have a relatively large intestinal tract area, have shown that a more prolonged contact with the antibiotic during the storage period is apparently necessary to obtain any significant prolongation of keeping quality. The effect of the intestinal tract area is even more exaggerated in such large fish as tuna, where spoilage inside the intestinal tract becomes of increasing importance, in addition to that starting on the outside.

The average uptake of CTC by the fillets was 0.598 gamma per gram, with a range of 0.224-1.32 gamma per gram.

Summing up all the observations made, it can be said that a treatment with an antibiotic, such as chlortetracycline (CTC), has a definite beneficial effect on the subsequent keeping quality of rockfish and sole fillets and of round flat fish, including sole species, dabs and flounders. The extent of the prolongation of the keeping quality was dependent, among other factors, on the storage temperature, the original bacterial load and history of the fish from time of catch to that of landing ashore.

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Maintenance of High Quality in Fish Fillets with Acronize

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Much of the present day literature regarding food products concerns the extension of storage and shelf life. After a certain period of time all edible fresh foods are subject to deterioration and decay. The primary causes of spoilage, in the order of appearance, are bacteria and autolysis. Bacterial spoilage is the most rapid, therefore the most important single problem is to slow or stop their growth. Because Aureomycin-chlortetracycline is a broad spectrum antibiotic, studies were conducted on poultry, fish, and red meats to assess its value as a preservative.

Kohler et al. (1955) have demonstrated the efficacy of chlortetracycline in preserving the freshness of poultry. Tarr and co-workers (Tarr, 1944; Tarr and Deas, 1948; Bissett and Tarr, 1952; Tarr, Southcott and Bissett, 1953; Boyd, Brumwell and Tarr, 1953; Tarr, Boyd and Bissett, 1954) have been investigating various preservatives including fourteen antibiotics. They report that of all the compounds tested, Aureomycin-chlortetracycline was the most effective inhibitor of the natural bacterial flora. Recent studies by Farber (1954) indicate utility on fish and shellfish. Firman et al. (1955) report good success with several other species of fish. Tomiyama (1955, 1956) has reported the efficacy of Aureomycin-chlortetracycline in prolonging the shelf life of round fish. Deatherage and co-workers (Cahill et al. 1952; Lepovetsky et al. 1953; Goldberg et al. 1953; Weiser et al. 1953, 1954) have reported utility in inhibiting bacterial growth in beef, using infusion techniques. From all these reports it appears that a broad spectrum antibiotic, such as chlortetracycline, is effective in extending the shelf life of many perishables. Since November 30, 1955 its use in or on freshly killed poultry has been permitted (Federal Register, 1955) and the food grade chlortetracycline has been formulated into a product called Acronize.

Fish is a competitor of meat and poultry in the diet. Yet people in the United States eat very little fish in comparison with the meat they consume, or with the fish consumed in other lands. This difference is partly due to the fact that a large proportion of the population lives in inland areas remote from the sea coast, and since fish are highly perishable, a difficult marketing problem presents itself. Use of fish in the diet may increase greatly as new scientific facts become understood and applied. This means continual changes in producing, processing, and marketing to improve the quality of the product. Acronize is one of these recent scientific advances which may greatly help the fishing industry to maintain the high quality of its products and to reduce significantly the great losses suffered by the industry.

There are various ways in which fish are prepared for the market. Fresh fish, usually the most desirable, are kept from spoiling by being packed in ice aboard the boat immediately after catching. In this way they can be kept in good condition for long periods. The largest percentage of these fish are filleted,

because of the relative ease of supplying distant points for both the fresh and frozen markets.

An Acronize-chlortetracycline dip can maintain the high quality of freshly cut fillets for days longer. In fish processing plants various dips are employed which serve a multiple purpose; 1. To clean the fillets free of slime and scales which may have collected during filleting; 2. To reduce "drip" during thawing of the frozen product; 3. To reduce the bacterial population. Now, with Acronize, an effective bacteriostat is imparted to the fillet through a simple dip containing 10 parts per million of antibiotic. Dipping times ranging from 15 to 30 seconds are encountered in most processing plants and shall be considered, for all practical purposes, as instantaneous dips. Microbiological assays

TABLE 1

CHLORTETRACYCLINE ASSAY OF FISH FILLETS (mcg/g)
vs.
DIP TIME (mins.)

Instantaneous 15-20 Secs.	1	2	5	15
0.55	0.63	0.79	0.79	0.95

The increase in weight of fillets as opposed to time is shown in Table 2.

TABLE 2

WEIGHT INCREASE IN FILLETS (%)
vs.
DIP TIME (mins.)

Instantaneous 15-20 Secs.	1	2	5	15
0.6	1.4	—	1.7	2.3

Increasing the concentration of chlortetracycline in the dip solution will also impart more antibiotic to the fillet (Table 3).

TABLE 3

FLESH ASSAYS (mcg/g)

Kind of Fillet	Dip Time Mins.	Concentration of Dip Solution		
		10 ppm	50 ppm	100 ppm
Flounder (lean)	5	0.46	4.25	10.20
	15	0.70	5.47	12.20
	30	0.89	6.87	18.22
Mackerel (fatty)	5	0.21	1.65	4.68
	15	0.28	2.40	5.82
	30	0.34	2.78	7.18

reveal proportionately larger amounts of antibiotic activity in fillets which were immersed for longer periods of time in an antibiotic solution, but it can be seen that the amount of chlortetracycline does not increase greatly with time (Table 1).

For any given dip time, if there is a five-fold increase in chlortetracycline concentration an eight-fold increase of antibiotic activity is found in the fillet. Increasing the concentration of the dip ten-fold shows a twenty-fold increase of antibiotic activity in the fillet. However, at any given concentration, if the dip time is prolonged three-fold or six-fold, less than a doubling of the amount of chlortetracycline is found in the fillet. Thus, it is seen from the data that the amount of antibiotic activity found in fillets or steaks is a more direct function of solution strength than immersion time.

Many persons are greatly concerned about consuming the small amount of

TABLE 4

CHLORTETRACYCLINE COOKOUT IN FISH FILLETS
CTC ASSAY—mcg/g
DEEP FAT—190°C

	0 mins.	2.5 mins.		5.0 mins.		7.5 mins.		10 mins.	
Kind of Fillet	CTC assay raw mcg/g	Average of positive samples mcg/g	negative samples %	Average of positive samples mcg/g	negative samples %	Average of positive samples mcg/g	negative samples %	Average of positive samples mcg/g	negative samples %
Flounder	0.50	0.115	none	0.061	40	neg.	100	neg.	100
Haddock	0.27	0.055	none	0.04	66	neg.	100	neg.	100

COOKING
5 minutes = light cook
7.5 minutes = average
10 minutes = well done

TABLE 5

CHLORTETRACYCLINE UTILITY ON FISH FILLETS
MICROORGANISMS x 10^6
ORGANOLEPTIC SCORES
DAYS AFTER PROCESSING

Kind of Fillet	6		10		13		17		20		24	
	count	score	count	score	count	score	count	score	count	score	count	score
Haddock												
Untreated	0.181	9.0	10.3	8.0	72	7.8*	111	4.0	410	1.8	—	—
Treated	0.08	9.8	0.15	9.8	0.63	9.2	34	7.4	92	6.3*	283	4.0

LEGEND FOR ORGANOLEPTIC SCORING

Excellent	9.5-10	Fair	6.5-7.4
Very Good	8.5-9.4	Poor	5.5-6.4
Good	7.5-8.4	Unacceptable	<5.4

The asterisk denotes that spoilage took place at a time between the stated sampling times but not at either one of them.

antibiotic found in raw fish flesh. Governmental regulatory officials share this concern. Under average cooking conditions it has been shown that practically all the antibiotic activity is destroyed. In effect the housewife has her fillet or steak protected from the processing plant up to the frying pan.

When fillets or steaks contain excessive amounts of antibiotic and are then cooked, proportionately more antibiotic is destroyed, but not all is deactivated.

Acronize treated fillets will continue to be of high quality for days longer, as adjudged by bacterial counts and organoleptic observations. The overall appearance, texture, odor and color are the criteria which gave the resultant organoleptic scores shown in the following table. Good utility of the antibiotic as a preservative is demonstrated.

It is of interest to know how long a solution containing 10 parts per million of chlortetracycline can be used without itself becoming exhausted or acting as a source of contamination. In work done by Hartshorne (1947) the bacterial population was shown to increase greatly in brining tanks and could be considered a potential source of contamination. In our studies we made no actual microbiological counts on the dip solution after continued use. Any contamination of a fillet should be and is reflected in the keeping quality of that fillet.

Studies were made in which several thousand pounds of fillets were treated with solutions containing 10 parts per million of chlortetracycline. All fillets remained in the solution approximately 20 seconds. On the basis of microbiological assay, bacterial counts, and organoleptic ratings we recommend for commercial purposes a ratio of 15 pounds of fillets per gallon of Acronize solution. This ratio is designed to insure consistantly uniform results with the commercial use of Acronize FD. Of course it must be emphasized that low temperatures should be maintained in the antibiotic dip.

It should be kept in mind that Acronize must never be used as a substitute for sanitation or refrigeration, nor as a redemption measure for poor or marginal fishery products. Rather, it has been designed to enhance the value of good sanitary and refrigeration practices. Acronize is a process which will reduce decay in fish products by retarding bacterial growth; it will accomplish this without injury to the food and without affecting its flavor. It is not toxic in the amounts used and is largely destroyed on cooking. Its cost is moderate, it is very practical and can be made readily available upon appropriate governmental clearance. Thus, it will undoubtedly replace, in ever increasing measure, dips which are popular today.

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Industry-Government Liaison in the Development of Breaded Shrimp Grade Standards

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PERHAPS A MORE DESCRIPTIVE TITLE for this paper would be "Cooperation and Compromise—the Inside Story of the Development of Voluntary Grade Standards for Breaded Shrimp." Except for the commendable cooperation between the members of industry and the government technologists working on standards, there would be nothing worth reporting today. Fortunately, all parties concerned were willing to compromise on details, and as a result there is now a proposed set of standards which will be workable and useful.

Since its inception in January 1955, the prime function of the Technology Division of the National Fisheries Institute has been to foster understanding and cooperation within the industry, and between government and industry. Working under a Saltonstall-Kennedy contract with the Bureau of Commercial Fisheries, the N.F.I. technologists have served as liaison agents in a quality improvement program, which includes the development of voluntary grade standards desired by the industry.

In 1953 the breaded shrimp industry made the first attempt to improve its products and its marketing through voluntary standards. A majority of the producers agreed to a set of tentative industry standards for the maximum amounts of breading to be permitted. These standards, however, were not universally accepted nor implemented. This first attempt, therefore, proved ineffectual.

Two years later at a meeting of shrimp breaders, during the N.F.I. convention at New Orleans, it was again agreed that quality and marketing improvements were seriously needed. The committee of breaders asked the N.F.I. Technology Division to canvass the industry and ascertain the desirability and practicability of some type of voluntary grade standards. Accordingly, the entire breaded shrimp industry was first questioned by mail. Then three open meetings were arranged for June and July, 1955. At these meetings in Miami Beach, Houston and Los Angeles the advantages and disadvantages of various possible standards were reviewed. The quality factors which should be considered in any standards were discussed. However, the producers postponed any specific recommendations until they could see a sample standard. At each of the three meetings it was unanimously requested that such a sample be prepared for serious review by the entire industry.

In order to fulfill this request our Division turned to Fish and Wildlife Service technologists for assistance. Together we prepared a working draft of possible standards for grading breaded shrimp. This draft was styled after voluntary grade standards being employed satisfactorily for several food products by the Agricultural Marketing Service. The definitions and other details in the draft were based on available laboratory data and on the quality factor suggestions made at the summer industry meetings.

Those industry meetings and that working draft were the beginnings of a series of both meetings and drafts. There have been sixteen public meetings called to review and discuss breaded shrimp standards. The provisional set of

standards reviewed in November, 1957 by the industry is at least the twelfth draft. Each meeting and each draft has represented significant progress towards a practical and well understood set of standards.

A comparison of the latest draft with the early draft reveals tremendous improvements in simplicity, clarity and practicality. Contributions to these improvements came from several of those concerned with the development of the standards. For example, the simple style of the present version is primarily the result of suggestions made by members of a special industry technologists' committee. The scoring procedures are based mainly on laboratory investigations conducted during the last three years by College Park technologists of the Bureau of Commercial Fisheries. Many refinements and modifications were suggested by the Breaded Shrimp Evaluation Programs held in connection with the last seven annual conventions of the National Fisheries Institute. A better understanding of the proposed standards and also a few more refinements resulted from the special evaluation seminars and demonstrations conducted this past summer.

The basic concepts of the first and last drafts are essentially the same. The grading procedures have been altered moderately, and these procedures have been considerably more refined and more clearly defined. Reading through the twelve drafts in chronological order, one can see adjustments which recognized normal processing and marketing practices and problems. Some grading requirements have been relaxed, others have been made more strict. These changes have been dictated by the results of laboratory studies and plant experience. The present draft promises to accomplish effectively the basic goal of all standards: it will differentiate reliably, the good, the fair and the poor products. It should therefore tend to encourage quality improvements and marketing improvements.

The Relationship of Residual Oil and Menhaden Fish Meal Quality

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FISH MEAL QUALITY has been a controversial subject for a number of years and continues to be the object of intensive research. Processing variables such as time and temperature in cooking, pressing, drying time and temperature and curing methods are being studied by the Fish and Wildlife Service in order to determine what relationship they have to the nutritive value of the meal. Similar and additional studies are also being conducted within the menhaden industry.

Curing studies conducted by personnel of New Jersey Menhaden Products have resulted in the use of antioxidants to eliminate the necessity for heat curing menhaden meal. This technique is rapidly being adopted by fish meal producers wherever heat curing presents a production and handling problem. Initial studies with antioxidants such as diphenylparaphenylenediamine (DPPD) and butylated hydroxy toluene (BHT) indicated that effective protection

against oxidation was dependent upon a number of factors. The most significant of these were:

1. Dispersion of the antioxidant
2. Degree of unsaturation of the residual oil
3. The time, temperature and method of drying
4. Moisture content of the meal
5. Presence of organic oxidation catalysts

Two and one half years of production experience have confirmed the importance of these factors.

Original studies were conducted using from two to three pounds of antioxidant per ton of fish meal. Since this level constituted a substantial production cost, it became desirable to reduce the antioxidant concentration to the lowest level which would provide the necessary degree of protection against oxidation. Although the iodine number of the residual oil was known to effect the stability of the meal, very little data on the day to day variations were available. In order to provide basic information on the relationship of the iodine number to the requirement for antioxidant, a record of the iodine number of each day's oil production with oil yield during the 1957 season was maintained at Wildwood, New Jersey. These data are presented in Figure 1.

The correlation between the iodine number and the oil yield expressed in gallons of oil per thousand fish (750 lbs.) is apparent.

The variations in the oil yield and the iodine number would indicate that a wide range of conditions existed within the area fished. Examination of the fishing vessel logs indicated that the variations observed were in part related to the area in which the fish were caught. On the basis of chemical and physical characteristics of the oil four populations were established:

1. Area off northern Virginia, Maryland, Delaware, southern New Jersey and Delaware Bay.
2. Area off central and northern New Jersey.
3. Hudson River basin and area off Long Island.
4. Migrating fish which entered northern New Jersey waters during the first week of October.

The fish taken in areas one and two appeared to be under estuarine environmental conditions. The oil from these fish contained varying degrees of chlorophyl pigmentation, with this condition being most pronounced in fish taken in Delaware Bay. The Delaware Bay fish which were largely from the 1954 year class, produced low yields of oil with the highest iodine number values observed during the season. Fish taken along the New Jersey coast during the main part of the season were from the 1953 and 1954 year classes with the former predominating along the upper New Jersey coast. Fish caught east of the Hudson River basin and south of Long Island appeared to be under an oceanic environment. Oil yields were much higher, the iodine number was lower, chlorophyl pigmentation was absent and the fish were much heavier. The lack of chlorophyl pigmentation suggests that the food was predominately zooplankton rather than phytoplankton of the coastal estuarine system. On the basis of these observations it would appear that the plankton population along the New Jersey coast was abnormal over a greater part of the 1957 season.

Migrating fish entering the fishing grounds during the first week in October

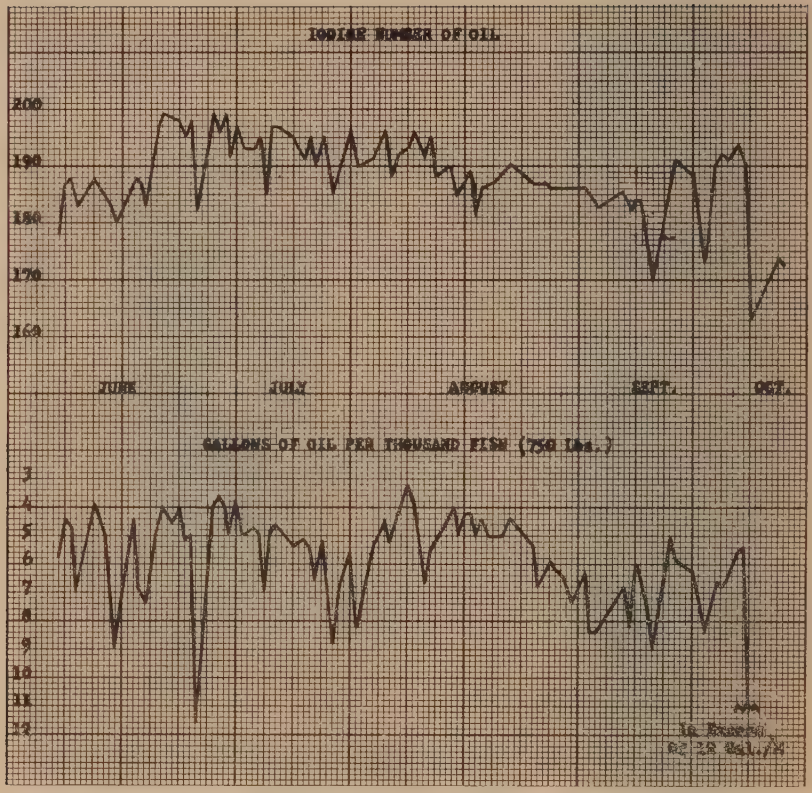

FIGURE 1. Oil Yield and Iodine Number Values for 1957 Menhaden Production Season, Wildwood, New Jersey.

were in excellent condition. On reduction these fish produced meals with 64-65 per cent protein, high oil yields with average iodine number of 172 and from traces to complete absence of chlorophyl pigmentation. A large part of these fish were from the 1953 year class with smaller numbers of older fish. The marked contrast in size and condition of fish of the same year class that entered the fishing ground in the fall and those present during the summer further indicate the difference in environmental conditions.

The biochemical variations in the oil present in the menhaden represent only one of the factors in the raw materials that may have an effect upon the quality of the meal produced. The amount and iodine number of the oil has a direct bearing on processing problems. The mechanisms involved in the oxidation of the oil in both fish flesh and in fish meal are being actively investigated. Dr. Harold Olcott of the University of California in his presentation before this group last year discussed the role of certain organic catalysts and their effect on oxidation of fish oil. Although much of Dr. Olcott's work has been with

tuna, menhaden are similar in some respects in that they are one of the more active marine fish and have a well-developed lateral band of red muscle. The physiological role of this red muscle is not well understood; however, it has been shown to be high in iron-containing proteins. The protein myoglobin, which is present in the red muscle, is similar to hemoglobin in that both contain a hematin group or groups. The cytochrome enzymes which also contain hematin groups are present in the red muscle of menhaden. Although these proteins are denatured during the normal course of processing into meal, the catalytic properties of the hematin groups apparently are not affected. This is brought out very strikingly when the moisture content of antioxidant stabilized meal is increased significantly above ten per cent. Under these conditions oxidation will occur, whereas at a moisture level between six and nine per cent the product is very stable. When hematin catalysts are inactivated by prior chemical treatment an increase in moisture does not bring about rapid oxidation of antioxidant stabilized meal.

From the data presented it is apparent that the biochemical composition of menhaden varies considerably and represents factors which require further study. One of the possible consequences of processing menhaden which contain highly unsaturated oils is illustrated by the results of two feeding studies. The meals were prepared from the same lot of fish with the only difference being that one was processed with the antioxidant BHT in order to minimize oxidation and the other was allowed to undergo rapid oxidation. The antioxidant processed meal had a grey-brown color and oil extracted from the meal had an iodine number of 162. The oxidized meal was reddish-brown in color, the oil was more difficult to extract and had an iodine number of 108. Proximate analysis values were comparable.

In the first feeding trial weanling albino male rats were used with two lots of four rats on each treatment. Feed and water were fed *ad libitum*. The diets employed contained 14.5 per cent protein and are shown in Table 1.

TABLE 1

RAT DIETS EMPLOYED FOR EVALUATING THE NUTRITIVE QUALITY OF FISH MEAL

Corn Starch	7	Vitamin-Mineral Mix	1
Corn Meal	64	Dical. Phosphate	1
Dried Whey	6	Alfalfa Meal	6
Corn Oil	2	Salt	1
Fish Meal	12		

The initial, ten day and twenty-eight day weights are shown in Table 2. There was no apparent palatability effect as both groups consumed approximately the same amount of feed. The condition of the rats was good, with the only difference being in the rate of gain which at 28 days was fifty seven per cent greater for the antioxidant processed meal. The results suggest that the overall nutritive value of the antioxidant processed meal was greater than for the meal which had been subjected to the effect of the rapid oxidation of the residual oil. Since the level of meals employed was high it is not known whether the reduced rate of gain is due to impaired protein quality, oxidative

TABLE 2

EFFECT OF FISH MEALS ON WEIGHT GAIN OF WEANLING ALBINO MALE RATS

Treatment	No. of Rats	Initial Av. Wt.	10 Day Av. Wt.	28 Day Av. Wt.
12% Heat Cured Fish Meal	8	65 gms.	103 gms.	155 gms.
12% Stabilized Fish Meal*	8	68 gms.	135 gms.	226 gms.

*Fish meal stabilized with BHT

degradation of the oil or a combination of these factors.

The second feeding trial was conducted with day old Arbor Acre White Rock chicks. The two meals were evaluated as a part of an experiment designed to determine the effect of oxidation on protein quality and unidentified growth factor activity. Four treatments were used with duplicate pens each containing twenty-five male and twenty-five female chicks. The birds were group weighed at four weeks and individually at eight weeks. The diets employed are given in Table 3.

TABLE 3

BROILER DIETS EMPLOYED IN EVALUATING THE NUTRITIVE VALUE OF FISH MEAL

Ingredients	*Diets*			
	1.	*2.*	*3.*	*4.*
Yellow Corn	51.95	60.95	56.80	60.95
SBOM (44%)	34	25.5	27.5	25.5
Alfalfa Meal	2	2	2	2
Dried Whey	2	2	2	2
Fish Solubles	2	—	2	—
Menhaden Meal				
Heat Cured	—	5	4	—
Stabilized	—	—	—	5
Corn Oil	4	1.5	2.65	1.5
Bone Meal	3	2	2	2
Salt	0.5	0.5	0.5	0.5
Vit-Min-Mix	0.5	0.5	0.5	0.5
TM-10	0.05	0.05	0.05	0.05

All of the diets are deficient in methionine according to the National Research Council recommendations. The diets were formulated in this manner to make methionine the first limiting amino acid in order to detect differences in methionine or methionine sparing factors in the fish meals under investigation. The four week group weights and eight week weights and feed efficiency calculations are presented in Table 4.

The four and eight week data indicate that the performance of all groups was within the normal range. In comparing the performance of the first group

TABLE 4

EFFECT OF FISH MEALS ON THE GROWTH AND FEED CONVERSION EFFICIENCY OF BROILERS

Treatment	No. of Broilers M.	F.	Av. Wt. (lbs.) 4 Wks.	Av. Wt. (lbs.) 8 Wks. M.	F.	Feed/Gain 8 Wks.
1. Basal with CFS	50	49	1.17	3.35	2.63	2.26
2. Basal with 5% Heat cured meal	50	48	1.17	3.36	2.65	2.28
3. Basal with 4% Heat cured meal + 2% CFS	50	50	1.25	3.42	2.73	2.25
4. Basal with 5% Stabilized meal	51	49	1.25	3.50	2.67	2.23

of birds receiving the basal diet with condensed fish solubles and the second group receiving the basal with five per cent heat cured fish meal little difference is observed even though the methionine level is 0.03 per cent higher in the second group. Although methionine is deficient in the diets of both groups a growth factor deficiency also tends to limit performance in the fish meal supplemented group sufficiently to offset the difference in the total methionine content of the diets. When solubles were added to the heat cured fish meal supplemented diet in group three there was an improvement in performance over the birds receiving either a condensed fish solubles supplement or heat cured fish meal supplement. The birds in the fourth group receiving a diet identical to the birds in the second group, except for the substitution of antioxidant processed meal, show an improvement in weight gain and feed efficiency which appears to be the result of more rapid growth of the cockerels. On the basis of the data available it is not known whether the improved performance of the birds in group four is due to a higher level of available methionine, higher unidentified factor level or a combination of both.

The data presented here is by no means conclusive but it suggests that the oxidation of fish meal during curing does have an effect on its nutritive value. Studies currently in progress in our laboratory are designed to provide additional information which we hope will contribute to a better understanding of the factors involved in fish meal quality.

Safety Engineering in the Fishing Fleet

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COMMERCIAL FISHING has always been regarded as a hazardous occupation by the general public and by the interested insurance underwriters—in short, by everyone except the people engaged in fishing. This lack of hazard appreciation is one of the greatest problems to be solved if we are to make commercial fishing safer, for the fishermen themselves are prone to treat with contempt the efforts

of insurance underwriters and owners to make their work safer, under the assumption that someone is bound to be hurt occasionally, no matter how careful he may be.

Before going into the hazards of the southern fishing industry, let us look at safety engineering in the broad sense. To me, safety engineering is the application of 10 per cent of engineering and 90 per cent common sense to the task of building and working a fishing vessel so as to minimize the exposure of the crew to accident. Engineering will never eliminate the peril of the sea: when the sea is running and the glass is falling only the skill of the competent water-man can assure the safety of the vessel and her crew. This was true in the days of sail and it will be equally true in the days of atom-powered vessels.

What safety engineering should do for the fisherman is to eliminate the needless accidents which cause men to lose their lives and livelihood and which cause financial loss to crew, vessel and owner. In short, when a trawler rears up on a sea and a crewman loses his balance and claws frantically for a rail or shroud to keep from going overboard, safety engineering should have already supplied the rail for his fingers to grasp; when the winch-man loses his balance as he takes in the trawl, he should fall against a safety rail, not into the moving drums of the winch.

Having roughly defined safety engineering, let us examine why boat owners and operators should be concerned with it, apart from an altruistic interest in the welfare of employees. In the final analysis, every problem relating to a fishing vessel boils down to dollars and cents and it is on this practical basis that safety engineering and good safety practices should be discussed. In New England, where accidents in the fishing fleet are common and where juries are excessively sympathetic to litigating seamen, the cost of Protection and Indemnity insurance may run as high as $500 per man per year. Here in the South, where accidents are not as frequent and where the average seaman is not as litigation-conscious, the average cost of P & I insurance is around $125 per man. Actually, there is no limit to the cost of insurance: as losses increase, so do the premiums charged for insurance. Therefore, the first benefit to the owner is a saving in insurance cost.

Consider, however, the owner who loads his vessel with ice, fuel and provisions for a 45 day voyage to the Campeche Banks, sending her off with high hopes, only to have an injury force his captain to land in Mexico for medical aid. If the captain is injured he may well stay in Mexico, sending the vessel to sea under command of the striker. It is unlikely that a good trip will result, and in addition to medical bills, port charges, etc., the owner will be short fifty or perhaps one hundred boxes of shrimp. It has been estimated that the "hidden costs" of an accident exceed the out-of-pocket costs by 7 to 1 and there is every reason to believe that this ratio is accurate. Therefore, let us not look at accident prevention with the eye of the social worker, interested in the health and welfare of the worker, but let us look at it instead with the skeptical eye of the cold-blooded capitalist to whom a fisherman might just be another cog in a larger machine. From this standpoint, accidents to fishermen interfere with the profitable operation of the vessel and must, therefore, be controlled. In short, let us assume that a blown head gasket on the main engine and the captain laid up with an injury are both equally undesirable.

To recapitulate, accidents on the boat cost the fisherman misery and the owner money and must, therefore, be reduced or eliminated. Now, assuming that

a given fleet of vessels practices good safety engineering and goes out of its way to reduce accidents, what sort of improvement can be expected?

Here we leave the sea momentarily, for data on accidents in the fishing fleet are hard to come by; instead, we will turn to a hazardous occupation on land, that of logging and wood handling. Pulpwood handling has always been regarded as hazardous and the premiums for Workmen's Compensation have been little short of scandalous. One large firm discovered that their employees were suffering seven to eight leg injuries per week from wood hooks. After considerable thought and study, they equipped each employee in the wood yard with baseball player's shin guards, the padded type normally worn by the catcher. Leg injuries virtually disappeared and today average about five per year. This same firm, in 1945, averaged 45 disabling injuries per million man-hours worked; in 1946 they started an intensive safety campaign in all departments and today they average five disabling accidents per million man-hours worked. This program succeeded because top management discovered that in addition to lost wages and medical expense, the company suffered up to 50 different kinds of loss when a man was disabled, all of them individually small but cumulatively very large. This was money wasted and so reflected on the company management and had to be stopped. In short, accident prevention and good safety practice are criteria for judging a well managed operation, whether it is logging or commercial fishing.

While it is economically feasible for a large industrial firm to maintain a full time safety engineer, this is not normally possible for a fishing vessel operator, even with a fairly large fleet. The solution here is for every owner to act as his own safety engineer and actively seek out and correct hazardous conditions. To return to dollars and cents, the first $200 in costs of any accident are usually borne by the owner, the balance by his insurance underwriters. That same $200 will equip a vessel with safety hand rails port and starboard, a safety rail around the winch, a life ring on each side of the deckhouse and make the down payment on a war surplus life raft.

While few owners will actively seek disagreement with a capable captain, particularly over what both regard as a petty matter, the owner must make his influence felt when it comes to safety matters. Many fishermen dislike non-skid paint on the after deck. Some claim it increases the wear on the trawl but actually it is probably that their dislike stems from the fact that it is a little more difficult to shovel up trash on a non-skid surface. The owner can insist that the entire deck be painted with non-skid paint, particularly around the winch and, as a concession, have an area aft where the trash is handled to be painted with conventional smooth paints. Most captains will not argue with an owner when it comes to spending money and if the owner wants a safety rail around the winch, the crew will generally go along, even though they privately deride the innovation. Every winch man I have encountered who has worked with a safety rail, however, has been enthusiastic about its convenience, not mentioning the safety angle.

In looking for job hazards, we must not overlook the people who manufacture our fishing gear. It is axiomatic that we never have a trivial winch accident: when the winch grabs a man he's generally in trouble. Yet some winch manufacturers steadfastly refuse to make minor changes in their designs which would produce a safer winch.

Consider, for example, the gear and brake band guard on the typical three

drum shrimp winch. This sheet metal guard originated in the shrimp fleet to keep moisture off the bands and frictions. It also enclosed the gears, making it less liable for a man to entangle his clothing. By keeping the bands dry the winch-man had better control over his winch and thus operated a safer winch. Literally hundreds of these band guards have been fabricated by small metal shops in Tampa, Ft. Myers and the Gulf ports and still the winch manufacturers have not tumbled to the fact that the industry wants and needs this feature.

A similar example is the brake pedal on the typical three drum winch. Last year I made a simple study of winch brake pedals, taking data on the first 100 vessels I encountered as a surveyor. In 66 per cent of the vessels the winch-man or the captain recognized that his brake pedals were slippery and attempted to correct this condition by slipping a cotton glove or an old sock over the pedals. Since a serious winch accident may well stem from slippery pedals it seems only reasonable that an alert manufacturer would study this problem and try to correct it.

One field where the owner can operate usefully is in the raft department, for new expenditure of funds is required. Many owners who wouldn't think of driving to town without a spare tire on the car, cheerfully send a trawler 600 miles across the open Gulf with three ratty-looking life preservers in the forepeak. Like many fishermen, I take the position that water is for sailing on and fishing in, and it is a disaster either to mix it with good whiskey or to swim in it; consequently, I am a poor swimmer. Many of our fishermen cannot swim a stroke and rather than try to change their lifelong prejudices about water I would rather supply them with a sturdy lifeboat or raft, so that in an emergency they can get off the boat with minimum exposure to water. A life raft can be purchased war surplus for $50 or less; a small dory will run $150 and I presume that these amounts account for the scarcity of life saving equipment in the shrimp fleet.

Expense, however, cannot possibly be a valid argument when we come to life rings, for they can be purchased for about ten dollars each. During 1957 I inspected over 250 shrimp trawlers in Florida and the Gulf states and I did not see 20 life rings in the whole fleet. Those few vessels which boasted life rings generally had them stowed away under the spare webbing in the forepeak, in a spot guaranteed to take 20 minutes to dig them out. As long as there are fishermen and boats someone is going to fall overboard. When a man goes over the side in oilskins and boots he needs help, right then and there. He can't wait for his shipmates to go below and hunt a life preserver or life ring. The prudent owner can solve this problem by equipping his vessel with two life rings, each held in a rack on the side of the deckhouse, out of the way, but ready for instant use. The owner who goes first class always, even if it only costs 100 per cent more, can buy life rings with automatic flares that light as soon as the ring hits the water, an excellent idea for Campeche vessels.

Engine room accidents are relatively few in the shrimp fleet because of the small amount of time spent by the crew in the engine room. There is no substitute for a well built guard around all moving machinery, but the design of such machinery guards must always take into consideration that when a boat rolls the crewman will instinctively throw out his hands or feet to regain his balance. If the guard will not meet this requirement then it is inadequate and should be redesigned.

Main deck accidents, with the exception of winch casualties, will become less

likely as more of our trawlers convert to the two-trawl system. Fishing two large try-nets, one on each side of the vessel (which is what the new system amounts to), has eliminated much of the gear which formerly hung over the crew's heads as they worked on the afterdeck. Likewise, the danger of falling overboard on the afterdeck has been reduced, for the gear is set on an automatic pilot course and it is not as necessary to lean outboard to help clear the cables over the transom.

In the galley one construction feature could readily be engineered out of the vessel: the practice of running butane gas tubing from the stove through the "dog-house" abaft the deckhouse thence to the deck butane tanks. A leak in the tubing running through the dog-house will fill the engine room with gas, a situation ripe for explosion. To my way of thinking, the best place for butane tubing is in plain sight, running alongside a roof beam or in a spot where it is protected from blows.

One of the difficult problems involved in safety work in the fishing fleet is the problem of communication. Each owner or captain works almost entirely on the basis of his own experience. Since he has never drowned, he assumes he never will drown; never having lost an arm in the winch, it is difficult for him to see how it can happen to HIM. To other people, perhaps, but not to him. The fact is, however, that fishing vessel accidents rarely involve anything new—they have all happened before, frequently in the exact same way. It is important, therefore, that accident information be pooled and communicated, not by the insurance companies, who are remote from the scene and the day-to-day actualities of the industry, but by the vessel operators themselves.

I propose that the shrimp or fishing industry trade organizations, such as the National Shrimp Congress, recognize that safety engineering is a legitimate and vital function of a trade organization and that one of these organizations should set up a Crew Safety Committee which would be charged with collecting data on vessel accidents, informing their members of the details of the accidents and at the same time circularize their membership with suggestions for accident prevention.

In the final analysis, there is very little engineering involved in safety engineering and what little there is represents the "do-it-yourself" school of engineering. It is mainly a matter of common sense plus imagination plus enlightened self-interest on the part of owners and crew.

DISCUSSION

Exploratory Fishing and Technology Session

Discussion Leader: E. A. FIEGER

Discussion Panel: RAYMOND L. HAYNIE, JR., KARL ENVOLDSEN, THEODORE M. MILLER, LEO D. LEVINSON

Some Pilot Plant Scale Applications of Antibiotics for Fish Preservation

LIONEL FARBER AND PETER LERKE

Q. Haynie: What is the value of adding an antibiotic to brine for preserving menhaden?

A. Farber: I have had no experience with menhaden, but with sardines there is a benefit of at least twelve hours in preservation time under refrigeration.

Q. Haynie: Antibiotics are much less stable at a pH of 7 compared with pH of 4. Have any agents been used for fish preservation which include acids, such as citric acid?

A. Farber: In the commercial antibiotic preparations used for poultry and experimentally for fish, citric acid is present.

Maintenance of High Quality of Fish Fillets with Acronize

EDWARD F. KLINE

Q. Levinson: How much would the use of Acronize cost the fisherman and the processor?

A. Kline: For the fisherman it has been estimated at about $2 extra per ton of ice. In plant use, the extra cost for Acronize would be insignificant—only a tenth of a cent a pound to treat fish.

Q. Marra: What is the effect of the antibiotics on humans?

A. Kline: We eat very little fish raw. After cooking, there would be no appreciable amount of antibiotic left.

Hooper: (Comment) We know of patients who have had at least a gram a day of aureomycin for many years. We are talking here in terms of dips of 10 parts per million, or in many cases less, in addition to the fact that in the cooked product it is essentially destroyed. Even if you were to eat the raw uncooked fish at this level you would have to eat at least a ton of fish to consume one pharmaceutical dose.

Q. Saenz: What method do you use for the bacterial counts? What are the most valuable criteria of quality, bacteria counts, or odor?

A. Farber: For the bacteria counts we use a standard procedure. We weigh out the fish or prepare a pressed juice which is diluted and used for the count. We place little credence on the bacteria count.

Q. Envoldsen: At what temperature in cooking does CTC finally disappear?

A. Kline: The disappearance of aureomycin can take place at room temperature after a sufficient length of time. The higher the temperature in cooking the more rapid the eradication. With fish sticks or breaded scallops cooked for 90 seconds at 185° F we have found no active antibiotics.

Q. Envoldsen: I have heard that with chickens treated with aureomycin and kept for an extended time lose flavor.

A. Hooper: Experience in our laboratory does not find this to be so.

Breaded Shrimp Standards

HARRIS MAGNUSSON

Q. Kahn: Will standards affect the cost of production?

A. Magnusson: In the case of "lot inspection" the cost, if borne by the producer, would be the cost of the inspector at $4.50 per hour, which would include any necessary travel time and sample preparation. In the case of "continuous inspection" at the plant, the cost is approximately $7,000 a year. That includes continuous inspection for wholesomeness and a certification as to grade. On a package basis the cost difference would be about two cents on a 10 ounce package.

Q. Kahn: How long is the storage life for an individual package?

A. Levinson: With good conditions at zero breaded shrimp can be kept about fifteen months without any problem.

The Relationship of Residual Oil and Menhaden Fish Meal Quality

Thomas L. Meade

Q. Haynie: What explanation do you have for the apparent correlation between the value of the oil and the oil content of the fish?

A. Meade: We do not have sufficient information at this time, but it would appear that the degree of saturation of the oil is dependent upon several factors. First, we think that the age of the fish would be involved, secondly, the feeding habits and possibly third, the environment of the fish.

Safety Engineering in the Fishing Fleet

John S. Robas

Q. Levinson: Are the builders as a group cognizant of the safety requirements on a boat?

A. Robas: The builders are selling a product and they hope to please the customer, and a good many of our owners are not willing to spend an extra $50 for a guardrail. Most builders have taken steps to guard their machinery.

Q. Anderson: You made no mention of prevention of fires aboard vessels. Is there some specific reason?

A. Robas: I skipped it because I was running out of time. There are relatively few fires on the shrimp fleet. We have pretty well eliminated them with diesel engines, and hence no gasoline in the engine room, but on the average trawler we still have hazardous conditions around the galley with butane gas.

THURSDAY—NOVEMBER 14

Chairman—SETON THOMPSON, *Acting Director, Gulf and South Atlantic Region, U. S. Fish and Wildlife Service, Washington, D. C.*

Program for Crab Research on the Atlantic Coast

KENNETH DOWNES

Oyster Institute of North America, Beaufort, N.C.

A TWO YEAR INVESTIGATION will be undertaken on the blue crab, *Callinectes sapidus,* of the Atlantic Coast of the United States, with the objective of obtaining information on the causes of fluctuations taking place within the crab population. These years of scarcity and abundance may be greatly influenced by the environmental conditions to which the larval and juvenile stages are exposed. Thus, a knowledge of the factors exerting their influence in this direction may well lead to methods of predicting fluctuations in the number of crabs entering the fishery.

The available information on the life history of this species, in particular the survival and growth of the larval stages, is insufficient to give us an understanding of the optimum conditions present in the environment that lead to a successful propagation of crabs. We are aware, from migratory studies, that mating occurs in low saline water while development and hatching of the eggs occurs in higher saline water. It is believed that the female mates only once in her lifetime during the soft stage of her final moult. She has probably undergone 25 moults in the previous 12 to 14 months. The sperm from the male is retained in the seminal receptacles of the female until such time as the eggs are fertilized and extruded, in the middle Atlantic area, usually during the following summer. However, if mating occurs sufficiently early in the summer, the eggs may be extruded in that same summer with a subsequent hatch. These fertile eggs, attached to the swimmerets on the ventral surface of the abdomen, constitute the yellow sponge, or egg mass.

As development and differentiation of the embryo takes place, the yellow sponge assumes an orange to brownish-black coloration. Approximately 12 to 15 days later one to two million pelagic larval forms are liberated.

The newly hatched transparent larvae, known as first stage zoeae, measures 0.8 to 0.9 mm in length. These larvae are believed to pass through five to six zoeal stages before reaching the larval megalops and first true crab form in roughly four to six weeks.

In such an organism as the blue crab, which produces a large number of young but affords them no protection, it is felt that survival to maturity is influenced more by the effect of environmental factors on the larval stages than on the size of the spawning stock. Hence, this investigation will encompass laboratory studies of environmental factors and their effect on the survival and growth of the larval stages.

This research will be carried out at the U. S. Fishery Laboratory at Beaufort, North Carolina, where space and facilities have been provided. Sponge bearing females, collected from the local area, will be held in laboratory tanks containing filtered, aerated seawater. The filter, of course, will be of such con-

struction as to exclude from the incoming seawater, the debris that tends to accumulate in the holding tanks. These crabs are kept under observation and fed daily. After natural hatching of the eggs, the liberated zoeae will be removed from the hatching tanks.

It should be pointed out here that our initial efforts will be directed toward developing a successful technique for raising the first stage zoeae through their larval stages to the first true crab form. A review of the literature has shown that earlier investigations were unsuccessful in rearing the newly hatched crabs to the true crab form, although the third zoeal stage was attained.

In this study on individual and combined environmental factors, study methods will be modified in the light of initial findings.

To eliminate metals that might produce toxic effects, the larval crabs will be reared in plastic, enamel, and glass containers. Preliminary work has demonstrated that shallow pans are satisfactory if the water is changed continually so as to remove accumulated debris, which has a tendency to become enmeshed with the minute hairs and appendages on the tiny zoeae. Accordingly, it appears that these conditions can best be removed by a circulating system in various size development containers.

Population density as a factor influencing survival and growth in these containers will be approached by varying the water depth and initial number of first stage zoeae. Successive larval stages will be subjected to similar studies.

Salinity effects on growth and survival will be studied by diluting filtered sea water with demineralized water to produce gradations from normally high saline (30 parts per thousand plus) to fresh water. All larval and juvenile stages will be subjected to sharp as well as gradual salinity changes to note differences in toleration. Preliminary work indicates that first stage zoeae survived best in 20 parts per thousand to 35 parts per thousand salinity, with transfer to the varied salinities shortly after hatching. Below 18 parts per thousand, 100 per cent mortality occurred in three days.

Temperature, likewise, will be studied in relation to tolerance in larvae and juvenile forms, with gradual and abrupt changes. Temperature graduations will be obtained by initially cooling the sea water and rewarming it at desired intervals within vinyl tubing, thereby eliminating metallic ions. Such a system will permit the recirculation of filtered sea water and insure continued temperatures with separate salinity systems at a minimum cost and maximum efficiency. In this area our basic problem is that of cooling the sea water rather than heating, as is true in more northern laboratories.

In order to evaluate the effectiveness of different foods and food microorganisms on the survival and growth of all larval and juvenile stages, selected culture suspensions of phytoplankton, in particular certain dinoflagellates, and zooplankton, in varying concentrations, will be introduced to a series of development containers. Survival and growth of young crabs on each food or combination of food microorganisms will be determined by utilizing data from enumeration and measurement of samples from each population.

Pure cultures will be developed of suspected food microorganisms present in the marine environment and those obtained from stomach analyses of the zoeae, megalops and juveniles found in the plankton tows and seine hauls. In addition, the early larval stages of oysters, clams, crustaceans, and certain annelids will be cultured and tested. Macerated and strained meats of shellfish will also be tried as a source of food.

Studies on the physiological requirements of the larval stages may include the

addition to the sea water of different vitamins with selected trace elements.

Gas exchange, in relation to metabolic requirements will be considered in relation to the above, utilizing closed circulating systems.

To determine the effect of varying degrees of light on the growth and survival of larval stages, one series of development containers will be subjected to complete darkness, one series to semi-darkness and one to normal diurnal light fluctuations. From overhead fluorescent lighting another series of development containers will be exposed to continuous light. These tests will be repeated a number of times in order to evaluate the survival and growth of each population.

Evaluation of the effects of the above variables will be made separately and in combination. It is recognized that other environmental factors may interact, but throughout this study, emphasis will be placed on the above cited variables.

As pointed out earlier, while our work will be primarily concerned with the larval stages, when sponge bearing females are available, we anticipate interim studies on the adult females. These crabs will be held under controlled temperatures and salinities to determine if the development and hatching of eggs can be influenced.

Concurrent with the laboratory work, it seems advisable to collect field data with which we can attempt to test our laboratory findings. Thus, the Newport and Neuse Rivers will be sampled periodically for larval and juvenile crabs along with the collection of hydographic data. Tagging of adult crabs in these two rivers will be conducted to obtain an understanding of the dynamics within the population. In particular, we are interested in the distribution and movement of the local stock.

We realize that certain phases of this work or related projects have been undertaken in various laboratories along the Atlantic Coast. Thus, we plan to continue periodic visits to these laboratories to obtain further ideas and suggestions which may be helpful in carrying on this project.

It is felt that these studies may give us a better understanding of the influences exerted by environmental factors on phases in the life cycle of the blue crab. Furthermore, the data obtained will be subjected to appropriate statistical analyses in order to determine the relationship between changes in the environmental factors and periodic fluctuations, then this may prove to be a basis for devising methods of predicting years of abundance and scarcity for the blue crab fishery.

The Role of River Basin Studies in the Conservation of Fishery Resources

James T. McBroom

Coordinator, Branch of River Basins, U. S. Fish and Wildlife Service
Washington, D. C.

It is the job of River Basin Studies in the U. S. Fish and Wildlife Service, Department of the Interior, to see that the interests of fish and wildlife conversation are protected in the nation's program of water resource development. This is a large order.

During the current fiscal year, the Corps of Engineers is operating, con-

structing, or planning 790 projects under an annual budget of $636,000,000. The Bureau of Reclamation is operating, constructing, or planning 145 projects with an annual budget of $180,000,000. The Department of Agriculture, in cooperation with local groups of farmers, is assisting in the construction or planning of 288 small watersheds and a number of other flood-control or water-use projects under an annual budget of $39,070,000.

These figures, impressive though they are, add up to only a part of the picture. Applicants, permittees, and licensees under the Federal Power Commission are operating, constructing, or planning hundreds of other projects. This number is growing at an increasing rate each year. And this still is not all of the activity in the water-resource field. To mention another, the new Federal Highway Program, with all of its cuts and fills, will profoundly affect the characteristics of the nation's waters. Of particular interest to this group is yet another type of activity—dredging and filling of estuarine and coastal wetlands to provide for navigation channels or to make new sites for industry, commerce, and residences. Every one of the activities and every one of the projects affects fish and wildlife habitat to greater or lesser degree.

This big job has been made the main responsibility of the Branch of River Basins of the Bureau of Sport Fisheries and Wildlife, operating also in the interests of the Bureau of Commercial Fisheries and the Service generally.

These, then, are the proportions of the challenging task which the 163 men of our Branch are attempting to do. Fortunately, we don't have to go it alone. We ask for and receive cooperation and assistance from the State conservation departments and the other branches of our Service organization. For their helping hands, we are grateful indeed.

Obviously, River Basins is a streamlined, fast-moving investigational function. It has to be. When a research man tackles a problem, he continues his investigation until he finds his answer, no matter how long it takes. We do not have that opportunity. Our River Basins people must conduct scientific field studies which meet definite time limits set by the planning and construction schedules of the engineering agencies. Consequently, we are, perforce, a group of deadline meeters, operating constantly at flank speed. Somehow, in the brief time that we ordinarily have available for an investigation, we have to come up with recommendations that will protect fish and wildlife resources. Our men do it, day after day, and week after week.

To meet this challenge, River Basin Studies formulates what specific recommendations can be determined by the judgment of our field biologists in the time available for project investigation, but relies heavily on provisions in law or project-authorizing documents for reasonable changes—after the project is built—in project structures and operations. In that way, advantage can be taken of the latest techniques in fisheries and wildlife management throughout the life of the project.

In the brief, twelve year history of the Branch of River Basins, we have been preoccupied with building up our strength and staff and by attempting to keep pace with current project proposals. However, there is an ever growing list of projects whose basic authorization includes provision for these changes in operation and structure after they are built. This list and these provisions are like money in the bank for fish and wildlife conservation. They can be drawn upon throughout the life of these projects to provide for more effective conservation of these resources.

Our tremendous water program can be a threat to the very existence of the fishery resources of this nation if the conservation agencies don't do their jobs. Every mouthful of a clamshell bucket or a dragline scoop dug from the bottom of a stream or estuary takes away a piece of living space for the fishery resources of this nation and has other effects besides. Every fall of a control gate in a dam changes the regimen of the stream below it, and changes its fishery habitat characteristics.

What are we to do about it?

We have only one course of action. We simply must use all the knowledge and imagination we can muster to see that these projects are designed, built, and operated so as to result in the least damage to our fish and wildlife resources. We must also recognize that some of these projects have good potentials for the improvement and enhancement of fish and wildlife. We must capitalize on these potentials to the maximum extent. Finally, we must not hesitate flatly to oppose a project where we can demonstrate to the satisfaction of the Congress and the public that the adverse effects on fish and wildlife clearly overbalance the benefits to other interests from building the project. That, in broad general terms, is what we have to do. The next question is: How do we do it?

Fundamentally, our approach must be legal as well as biological. The water-development program of this country is carried out in accordance with laws adopted by our Congress. There are literally hundreds of these laws which cover water development generally, and water projects specifically and individually. Taken together, they establish the legal framework for the water-development program. It follows that a proper place for fish and wildlife in this program has to be obtained through legislative action and provisions in the project legal framework for fish and wildlife conservation.

One of these laws is the Coordination Act, adopted on August 14, 1946, sometimes known as Public Law 732, 79th Congress. The Coordination Act is the Magna Charta of River Basin Studies. What conservation authority we have for investigating and reporting on water projects is contained in this Act. It also provides the limitation on what we can do toward the conservation of fish and wildlife in the nation's water-project program.

Briefly stated, the Coordination Act of 1946 provides that there shall be an investigation by the Fish and Wildlife Service and the appropriate State fish and game agency of any project proposed by any Federal agency or any non-Federal agency under Federal license, for the impounding, diverting, or other control of the waters of any stream or other body of water. The purpose of this investigation is to determine the effects of the project on fish and wildlife resources and to formulate means and measures for incorporation in the project plan to prevent loss of, and damage to, these resources. The Act also provides that the report of the Fish and Wildlife Service shall accompany the engineering agency's project report when transmitted to the Congress, and that the cost of fish and wildlife conservation measures shall be considered as part of the cost of the project.

Be it noted that the Coordination Act is a permissive piece of legislation. It has no mandatory provisions binding on Federal agencies who license, construct, and operate water-resource projects. Consequently, the results for fish and wildlife conservation must be obtained largely by successful negotiation with these agencies. They, of course, are well aware of their legal option to adopt or reject any particular conservation measure. Under these circumstances, we can point

with some pride to the accomplishments under the Coordination Act. But, frankly, the Act in its present form is not nearly strong enough to maintain at an acceptable level the fish and wildlife resources needed to support the commercial and recreational interests dependent on them.

Here are some of the weaknesses of the Act. It has questionable application to dredging by the Corps of Engineers of navigation channels in the estuaries and coastal waters which are so important for commercial and sport fishery resources. It definitely does not apply to dredging and filling carried out by non-Federal interests under permit from the Corps. The Act is oriented toward prevention of damage and does not provide clear authority for construction agencies to take advantage of opportunities for the improvement and enhancement of fish and wildlife. Also, it has questionable application to the hundreds of projects authorized prior to 1946.

Last January, Ross Leffler, Assistant Secretary of the Interior for Fish and Wildlife, at the direction of Secretary Seaton, sent a draft of proposed amendments to the Governor of each state for review and comment. These amendments are designed to show up the weaknesses of the Act and to plug its loopholes. Within a short time thereafter, he received from each of the 48 Governors, or their authorized representatives, approving comments on the proposed legislation and a number of excellent suggestions for its improvement. Every national conservation agency of the nation has expressed approval of the proposed amendments.

Most importantly, these amendments would clearly authorize construction agencies to plan, build, and operate projects for the development and improvement of fish and wildlife, as well as for other purposes. They would authorize these agencies to acquire land for fish and wildlife purposes at Government projects. Significantly to the interests of the Gulf and Caribbean area, they would make the Act clearly apply to drainage and navigation projects of the type which are threatening the fishery resources in the estuaries of the Gulf of Mexico. The amendments would also make the Act apply to projects already authorized, no matter when the date of authorization, providing they have not been substantially completed. Taken as a whole, these amendments represent positive legislation which will give Federal construction agencies the authority to do a truly sound job in the fish and wildlife field. They will place fish and wildlife conservation on an equal partnership basis in resources planning.

Every man who makes his living, directly or indirectly, from the products of the sea or its adjacent coastal waters, has a tremendous stake in seeing that these amendments to the Coordination Act are adopted.

If the amendments are passed in the form proposed, we and you will be in a far better position to see that projects like the Mississippi River-Gulf Outlet canal will do the least possible damage to important shellfish habitat, fin-fish nursery areas, and waterfowl marshes of the Gulf coast.

It's worth noting here that the basic plan on which the Mississippi River-Gulf Outlet project was authorized was completed in 1946, just a few weeks after the passage of the Coordination Act. The plan was developed without benefit of, or request for, an investigation by the Fish and Wildlife Service, or the Louisiana Wild Life and Fisheries Commission. This plan calls for building a ship canal from the vicinity of New Orleans to the Gulf of Mexico in the Breton Sound area. The canal will be about 70 miles long, 500 feet wide, and 36 feet deep. Its purpose will be to shorten the distance for ships and boats from the Gulf to the

City, and to facilitate navigation. The canal is likely to have profound effects on the important fish and wildlife resources of the area through which it will pass. Its construction will disturb the bottoms by dredging and deposition of spoil, and it possibly will change the salinity of the water.

After completion of the plan for this project in 1946, it laid on the shelf for 10 years. Then it was authorized in 1956. Funds were made available for the preparation of detailed plans and initiation of construction just a few months ago. Under current budgetary policies, we can undertake the investigation of a project like this only when funds are transferred to us for that purpose by the construction agency. When that agency has no project funds, as was the case on the Mississippi River-Gulf Outlet project for 11 years after the plan was completed, we obviously cannot get project funds transferred to us for our studies. It should be made clear that funds for investigation of this project were made available to us at exactly the same time, a few months ago, that project funds were made available to the Corps of Engineers. Obviously, of course, the construction plans on this project are much farther advanced than the studies of the Fish and Wildlife Service, because of the planning work that the Corps did back in 1946. However, Secretary Seaton has formally requested the Secretary of the Army to do everything possible to bring the fish and wildlife planning for this project into balance with the construction planning.

What can we expect on the Mississippi River-Gulf Outlet? Clearly, the project is not going to be blocked or stopped. It has been authorized, and the initial construction funds have been appropriated. What we must strive to do is bring about the modification of plans so that the project will do the least possible damage to fish and wildlife resources. To do this, we need the findings of research on the effects of changes in salinity, changes in currents, the dredging of bottoms and the deposition of spoil on the shellfishes and fin-fishes of the Louisiana coastal wetlands. The Bureau of Commercial Fisheries has recognized this need, and has already put in motion plans to have this research started.

The need for this research has been recognized by the Bureau of Sports Fisheries and Wildlife for several years, in view of the very large program of the engineering agencies for modification of estuarine fishery habitat along the Gulf coast and the South Atlantic seaboard. Arthur Marshall, then in our organization, discussed this need before the meeting of this Institute last fall at Nassau. We are most gratified that aggressive steps are being taken by the Bureau of Commercial Fisheries toward finding some of the answers we need to formulate conservation recommendations, not only for the Mississippi River-Gulf Outlet project, but also for the some 40 other projects along the Gulf coast alone, which are in prospect for the next decade under the aegis of the Corps of Engineers. Furthermore, every hurricane prompts new demands on the Government to plan barriers or other measures to block disastrous waves from our shores.

The Mississippi River-Gulf Outlet project is a prime example of the importance of proper timing in river basins work. The plan was prepared 11 years ago; the most effective time for conservation recommendations likewise would have been 11 years ago. By the same token, we need to be working now on projects that will go into construction status 10 or 15 years from now. To get the job done right, we need to be heard at every major step during the years-long route from the conception of an engineering plan, through all of the inter-agency review processes, through review by the Bureau of the Budget, through con-

sideration of authorization by the Congress, and through the process of submitting estimates and getting project appropriations.

We assure you that we are putting in our oar at each of these steps on projects now in the planning mill. But you will have to take this on faith, because these projects, many of them, will not reach the construction stage for a decade or more. Consequently, the results of our efforts will not be apparent until then. Nevertheless, what we do today will determine how effective we are 10 or 15 years from now.

The role of the Fish and Wildlife Service in its river basin studies work is to lock the barn doors 10 or 15 years in advance of the horse's disappearance. We hope that we have the wisdom and the foresight to do the job.

Plankton and Fisheries in the Gulf of Mexico[1]

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We hope that before long it will be possible to start from Texas A. and M. a widespread survey of the plankton in the offshore waters of the Gulf of Mexico. Such a project could well be justified on academic grounds alone. Dr. Galtsoff has already reminded us that productivity studies in the open Gulf are amongst our most pressing needs. Clearly, considerable improvements in our current knowledge of standing crops and seasonal cycles of both phytoplankton and zooplankton will be necessary before such studies can become meaningful.

But the preparation of regular synoptic charts of plankton distributions may well also provide direct and indirect information of considerable importance to the Gulf fisheries; or, at least, this would seem likely from experience in the North Sea and adjacent waters.

Firstly, the use of automatic sampling gear from a variety of shipping should reveal concentrations of larvae in the plankton catches and so help to delimit more closely the spawning grounds of shrimp and commercially important fish. At the same time aggregations of species which are not at present exploited might be demonstrated by the distribution of their eggs and young. Unsuspected stocks of Blue Whiting, *Gadus poutassou,* were found by Henderson (1957) in this manner in the Atlantic, 200-300 miles west of Scotland.

Secondly, it seems likely by analogy with the North Sea that the natural fluctuation in the yields of the Gulf fisheries may be greatly effected by the interchange of water between the offshore and coastal waters and between the Atlantic and the Gulf. That is, by factors which, although they are tied in some way to these water movements, are not readily recognizable by conventional hydrographic techniques. As an example, one can cite the well documented collapse of the herring fishery in the western reaches of the English Channel during the 1930's (Kemp, 1938). Here, it was the younger age groups of fish which first declined in numbers, so over-exploitation could not account

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[1]Contribution from the Department of Oceanography and Meteorology of the Agricultural and Mechanical College of Texas, Oceanography and Meteorology Series No. 117.

for the drastic reduction in catch per landing. The contemporaneous change in the species of *Sagitta* in the area suggested to Russell (1939) that less Atlantic water was entering the western end of the channel and he proposed that the corresponding reduction in phosphates had led to less production of phytoplankton and so less food available for the fish fry. However, more recently, work by Wilson (1951) and Wilson and Armstrong (1952, 1954) has raised the alternative possibility that water of Atlantic origin may contain "growth factors" of vital importance to the healthy development of the young of some species. Whatever these factors may be, they are not at present recognizable by conventional techniques; their presence can only be deduced by the planktonic fauna that the water supports.

Such an idea has been very much in mind in studying the plankton surveys undertaken by the Edinburgh Laboratory of the Scottish Marine Biological Association. From the regular samples collected by the Hardy continuous plankton recorder it is possible to show a progressively earlier appearance of indicator species in the Atlantic Drift off the west coast of Ireland from 1948 to 1953. This entails a change in timing amounting to two months, from June in 1948 and 1949, to May in 1950 and 1952, to April in 1953 (Rae 1954).

Over the same period, the arrival of one of these "indicators," *Clione,* on the herring fishing grounds off the northeast coast of Scotland advanced by a corresponding time from August in 1949 to June in 1953 (Glover, 1955). Glover also demonstrates a southerly shift of about 150 miles in the most productive fishing grounds for herring during the same five years. It seems quite reasonable, therefore, to suppose that the spawning migrations of the herring are in some way affected by the advancing front of Atlantic water; a model which would equally explain the earlier observations in the channel. It may be that the mature herring can recognize the presence of those "growth factors" in the environment which are conducive to good survival of the larvae and so, within limits, select their spawning grounds.

There is further circumstantial evidence of the importance of Atlantic water to fish stocks in the North Sea. During each winter of the last 10 years, it has been possible to trace the movements of another planktonic indicator species, *Metridia lucens,* that is carried into the northern North Sea during the previous autumn. Along one axis, this movement can be correlated closely with the prevailing wind. Wind data are available for many years and so one has presumtive information on the orientation of Atlantic water relative to the haddock spawning grounds for the 32 years for which there are estimates of brood strengths of haddock. Comparison between the two sets of data suggests that strong broods—or good recruitment to the fishable stock somewhat later—do not occur in those years when relatively little Atlantic water covers the spawning grounds (Rae 1957). Here it is the conditions prevailing before the onset of spawning which appear to influence the subsequent survival of the young. Thus, again we may reasonably suspect that an adequacy or inadequacy of some beneficial factor that is carried into the spawning area each year from the open Atlantic, can have a controlling influence.

It seems to me, therefore, that although the major fisheries in the Gulf are concentrated near the coast, we cannot be confident that we will ever understand them by studying only the coastal waters. More effort should be devoted to investigations of the open Gulf. It may, indeed, prove necessary to learn a great deal more about the variations in the circulation within the Gulf, the

interchange between the Gulf and the Atlantic and the general ecology of the offshore fauna, if we are to answer the many questions already posed about inshore fisheries. We hope that the proposed studies of the plankton from our Galveston Laboratory will make one preliminary step toward this end.

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Oceanography and Fisheries

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MANY PAPERS HAVE BEEN WRITTEN about this subject, but few of them seem to stress what we consider to be the essential points. Many of the papers have been written by oceanographers who have attempted to show the successful use of hydography in fishery science. We would like to present a more critical view of some of the work which has been carried out by oceanographers, biologists, or both together, in order to suggest solutions to some of the difficulties which the fishery science has encountered. To do so, we must first clarify the objectives of oceanography and fishery science.

Physical and chemical oceanography has as its objectives the study of the sea itself: the physics and chemistry of the water masses, the currents, and (what are certainly the most important in connection with fishery science), the mixing processes in the ocean.

The ultimate aim of fishery science, in turn, is to increase the yield of fish per unit of fishing effort.

This is not the place to balance the efforts and successes of biologists, statisticians and oceanographers; instead we want to discuss some of the questions which have arisen in the conduct of fishery science in order to see what has already been done for the fisheries by scientists and to consider what factors have been studied in efforts to solve the problems of the industry.

Fishery science is concerned primarily with the characteristics of fish populations: how and why they change in size; what causes the schools to move from place to place. These questions can be answered not only in terms of biology of the animal, but also in terms of the environment. Hence, fishery science must seek help from oceanography before a complete understanding of the behavior of a fish stock can be achieved. It is our feeling that the collaboration between oceanography and fisheries has not been as fruitful as might be, and it is our purpose to examine why this has been so, and to suggest ways of improving the application of oceanography to fisheries in the future.

It would appear that some of the responsibility for the less than satisfactory application of oceanography to fisheries must rest on the oceanographer. Even though he may be engaged in a program which is designed to assist fisheries science, sometimes the oceanographer may become fully engrossed in a mechanical description of the ocean environment, without reference to whether the data gathered are useful to the fisheries problem or not. It is easier to collect data than to analyze it, and it is an unfortunate commonplace to have oceanographic programs continue to grind out observations without pausing to determine whether they have any meaning to the problem at hand. The effort in time and money may be worthwhile for the results in physical oceanography, but should be more applicable to fishery science. The knowledge of the dynamics and the movements of water masses is not necessarily useful for the fishery, but it is equally clear that the fisheries scientist must share the responsibility for these shortcomings. As fisheries emerges from the descriptive stage into the status of a quantitative science, it must increase its use of measurements of changes in environmental conditions. Much of the failure of oceanographic programs can be laid to a failure on the part of the fishery scientist to provide the oceanographer with a clear-cut problem. If the question posed is vague and inclusive as: "What are the characteristics of the ocean in this area?", the answer is bound to be correspondingly vague and thinly spread. Good answers from the oceanographer require careful guidance from the fisheries scientist. In many cases such guidance is impossible to provide because the necessary biological background is lacking. In this case it seems wasteful to conduct a "shot-gun" oceanographic investigation in the vague hope that "something will turn up." It seems more productive to delay the use of oceanography until a sound basis of biological data has been laid, to which the study of the environment can be intelligently applied.

It will be profitable to examine instances where oceanography has actually assisted fishery biology, since, although these may be few in number, they may indicate fruitful approaches for the future.

Fluctuations in the yield of fisheries are among the most important and difficult problems facing the fishery scientist. The stock on which the Norwegian cod fishery depends is a case in point.

Some help in understanding the fluctuations of a cod fishery have been obtained from oceanography. The cod spawns near the Norwegian coast and the hatched eggs float to the surface and are carried northward by the prevailing

current. After two or three years, the cod return from the northern waters to the spawning grounds. At this time they must find their way against the currents, and for this reason, the investigation of the current system outside Norway has been a very important hydographic contribution toward solving the problem of variations in catch in this fishery. Here we see that although the current is of great importance during one period in the life cycle of the fish, during another period the current does not seem to play a vital role. The question of how the cod is stimulated to return to the spawning grounds is a biological one, but we know nothing of the nature of this mechanism nor of the environmental factors which guide it.

There are species of fish in which the migration to the spawning ground is clearly triggered by biochemical changes in the fish. For example, in the case of eel, Professor Fontaine has shown that the female can be induced to start its spawning migration by surgical removal of the hypophysis gland. Of course, the question of how the eel finds its way to the spawning ground after the migration has been triggered still has not been solved.

It is commonly assumed that each reaction of an animal has its physical or chemical cause. For that reason the oceanographer dealing in physical and chemical measurements in the sea, is often asked to answer the question, "How do fish find their spawning grounds?", in the same way that the meteorologist is often asked how the birds find their way in their migrations. It is important to note that thus far neither the oceanographers nor the meteorologists have been able to find gradients which are of sufficient magnitude to indicate that by any given means fish or birds find their way. The oceanographer's job is made the harder because fishery scientists, lacking sufficient knowledge of the biology of their animals, have not been able to tell the oceanographer which variables may possibly affect these migrations. In our opinion, the question can only be solved by further study of fish behavior and the physiology of fish, rather than by finding a physical or chemical variable in the sea which would force the fish in a certain direction.

It is hard to see how a fish in more or less homogeneous water (for his magnitude it is completely homogeneous), can perceive a cline in temperature, salinity or whatever, which an oceanographer, using the most modern techniques and equipment can detect only over a distance of many miles. Therefore, if these variables *are* effective in controlling the movements of the fish, then we must assume that the animal is capable of retaining a memory of what the salinity or temperature was some time before, and is capable of relating this remembered condition to the one it is currently in. Moreover it had to know how to find its way back to the former environment if the new one should not be suitable. Here again biological work seems a necessary prelude to useful oceanography. We have few experiments on the reaction of food fish to the primary physical environmental factors such as salinity, temperature, and pH. Some of the most useful of these have been carried out by Dr. H. O. Bull of the Dove Marine Laboratory in England. Dr. Bull adapted the technique of Pavlov to train fish to react to sudden changes in one or another parameter. He found that a change of 0.03° C or 0.2/mil salinity or 0.05 pH will cause certain fish to react positively toward food. Since these are conditioned reflexes, the values are probably the minimum stimuli which produce reactions in these fish. Thus, while Bull's results do not necessarily prove that the fish will react at the same levels of stimuli in nature, they suggest again that the animal is

equipped with a memory for conditions previously encountered if it reacts to environmental changes in the sea. The assumption that some fish can retain a memory with respect to smell has been proved by the experiments of Hasler with salmon. No other experiments on this very important ability of fish are known to us.

By these few experiments, which show the effect of some isolated parameters on fish, we can see that the questions asked of an oceanographer sometimes cannot be answered, not only because of the ignorance of the oceanographer but also because of the often still greater ignorance on the part of the biologist in framing his questions.

Schools of fish are very often found in water of a certain temperature or within narrow temperature limits. When these limits are established, hydrographic research may indicate the possibility of easier location of this species, (although there is no assurance that fish will be found in all water masses within the temperature range). The fishermen of Lofoten, Norway, for example, are equipped with a simple thermometer and knowing that the cod appears only in water between 2 and 3° C they do not shoot their gear unless water of the right temperature has been found.

Mackerel can be caught outside the coast of Sweden in purse seines when the waters in the Skagerak are 9° C. Dr. A. Molander has shown that the velocity and direction of the wind are also of importance for predicting the appearance of mackerel in this area.

Sometimes, especially early in an investigation, it is necessary to investigate an area thoroughly with all the facilities of classical oceanography. On the other hand, when we know more about the behavior of a fish, it might become necessary merely to determine the variation of one parameter in space and time.

We know, however, that physical and chemical conditions of the environment do not act singly and independently upon an animal, and that false conclusions may be reached by observations of the apparent effect of one variable on the behavior or survival of a fish. It has been said that no attempt should be made to observe the effects of single environmental changes, but instead that we should measure all variables which affect the animal, and relate these to their effect on movements, growth, survival or other characteristics of interest. Now we are faced with a dilemma. In the first place, what constitutes "all" the variables? Obviously this is impossible to say. But even assuming a long list of variables can be prepared which will include nearly all those likely to be important, practical limitations of time, men and boats make it impossible to measure all of these. It is patently foolish, then, to sit back and say that no variables should be measured because they all cannot be. Instead it would seem to be wise to measure those which seem likely to be important, and which can be treated with the resources at hand, relate their effects to the fish as fully as the limitations of the data allow, eliminate those appearing to be of little consequence and concentrate on the ones which singly or in combination are of significance.

Furthermore, different oceanographic parameters are important to the fish at different stages of development. The newly hatched eggs and the larvae are highly dependent on currents. The distribution of larvae, (which usually are planktonic), is related closely to the current system around the spawning ground. As an example the cod has been cited above. Since the food supply consists mainly of phytoplankton during this period, the distribution of light

which determines the compensation depth is important, as is the supply of nutrients to the phytoplankton population. Consequently, planktonologists and oceanographers have always had a fruitful collaboration.

The adult fish has its most sensitive period when it is on its way to the spawning grounds. Fish behavior in this period is little understood, but we do know that the fish usually does not feed during this migration. We also know that temperature plays an important role in spawning. Fish which have arrived at the spawning grounds do not begin to spawn if the right temperature is not prevailing. Even after spawning has started if the temperature changes suddenly because of a change in the current or the wind direction, spawning may suddenly cease and begin again only when the proper temperature returns. Fluctuations in salinity do not seem to be important to spawning behavior, but the conditions of the spawning grounds are important, since the water around the eggs must have a high oxygen content.

During the feeding season the adult fish depends, in the final analysis, on the production of phytoplankton, which is the primary producer of proteins in the sea. This is the second way in which we see that the production of plankton is of great importance to a fish population (the first being that the survival of fish larvae is influenced by the planktonic supply of food). The role of oceanography in describing the distribution and occurrence of plankton and therefore assisting in the understanding of fish population dynamics is obvious. The plankton concentration depends on the supply of nutrient salts, which are a limiting factor. In addition plankton is dependent on light, temperature and enzymes. The nutrients are transported vertically from deep layers. The amount transported is dependent upon the total hydrographic situation. In coastal regions where prevailing winds blow from the land, deeper water is easily mixed with the surface water which is blown away. Over a bank internal waves break, which also results in increased transport of deep water to the surface. In the center of a fast-moving current, and in a hydrographic divergence, deep water enters the layer where light is used by phytoplankton for production of proteins. These regions are always known for their high productivity of fish. Examples are the Dogger Bank in the North Sea, the lee side of most oceanic islands, and the Grand Banks south of Newfoundland. The relationship of phytoplankton to fish is complicated because the food chain is a long one, but the influence is clear-cut.

Zooplankton is almost directly dependent on the supply of phytoplankton. Here the influence of oceanic conditions is more complicated, since the zooplankton is affected by physical properties of sea water, as has been shown by Dr. H. B. Moore. Light is the main influence on copepods. We find a diurnal vertical migration shown by all copepods following a particular light intensity. Contrary to the temperature, salinity, and pressure gradients, the light course is directly observable by animals because of the directional perception of the eyes and no memory is necessary (except in horizontal migrations where memory of diurnal change appears). There is only one physical property in addition to light which shows the same influence, and that is sound. Even if sound may be excluded for planktonic animals, it seems that it is important for fish which can also determine the direction to the sound source. Studies made at Woods Hole Oceanographic Institution demonstrate that it is possible to initiate sound production by fish in reply to artificial sound transmission in water. The story of the silence of fish has certainly been disproved.

Light influences the active movement of plankton, in a directional way; to what extent may temperature influence movement? It appears that copepods, transferred to a medium of unusual temperature and salinity, react with increased speed in a random way, but no directional movement is observed. The interaction of non-directional environmental factors with the directional one (light) creates a complicated pattern of migration.

Another factor which has gained importance recently because of the work of Provasoli, Collier, and others is the organic constituents dissolved in sea water, especially the enzymes, hormones, and the chelates of metals, all of which have been shown to influence the production of plankton. On the other hand, it seems that a planktonic population nearly always produces a toxin which works as a growth inhibitor, thereby limiting its own population. The production of these organic constituents in the sea has not been fully demonstrated as yet. It seems that some of them are produced mainly on land and transported to the sea. It may be that they are also formed in the sea and they are certainly formed on the sea floor, to some extent, by bacterial decomposition of organic matter. As one of the most important representatives of this group, vitamin B-12 may be mentioned.

Summary and Conclusions:

Through examples and the discussion of the approaches to fishery science, it has been made clear that oceanography very often is an integral part of the scientific study of fishery problems. We are now passing the descriptive stage in both sciences. The advances in biochemistry in the study of production in the sea, in the oceanographic understanding of mixing and circulation in the ocean, and in the study of the effects of physical parameters on the behavior of fish have now reached a point where they can be used in fishery science.

It seems obvious that extensive biological work is necessary on fish populations before useful work can be done by the oceanographers studying the environment. This biological work includes behavior studies in the laboratory and in the field, as well as life history work. When this type of work is well advanced, instructions can be given more clearly to the oceanographer, and the problem pinned down to specifics which are capable of clear cut solutions.

For his part, the oceanographer is urged to pay more attention than has been usual in the past to such variables as the mixing of ocean waters, the amounts of organic material, and the light.

Both sciences should insist on closer collaboration, both in the initial planning stages of programs, and in the re-examination of goals and procedures. As information accumulates current analysis of data is of paramount importance, since only in this way can unnecessary sampling be avoided and useful new directions of investigations be discovered.

Oceanography—the description of the oceanic environment for its own sake —can exist without fisheries, but most fisheries work will eventually need oceanography. It is important that the two sciences learn to develop a fruitful collaboration. We hope we have suggested some directions in which this might be accomplished.

Size Selection of Fish by Otter Trawls

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FISHING IS BY NATURE a very selective process. The selection results from the direction of fishing operations and from selective properties of the gear itself. Perhaps the most important of the selective properties of otter trawls is the selection of certain sizes of fish, since it is this property which permits the harvesting of fish stocks at the age which will ensure maximum production. The size selection of fish in otter trawls may be conveniently divided into two categories, extraneous and inherent.

Extraneous size selection is caused by factors other than those associated with the gear itself. The two major sources of extraneous selection are (1) nonrepresentative distribution of the fishing fleet over the total size distribution of the fish and (2) differential availability of different size groups within the fishing region. Selection from the first process will vary in response to seasonal or sporadic changes in either the distribution of the fishing fleet or distribution of the fish stock. Selection by the second process will be affected by changes in fish habits and behavior among areas, seasons and years. Little control can be exercised over either of these factors in management programs, but both are important in the application of biological sampling to the understanding of the structures of fish populations.

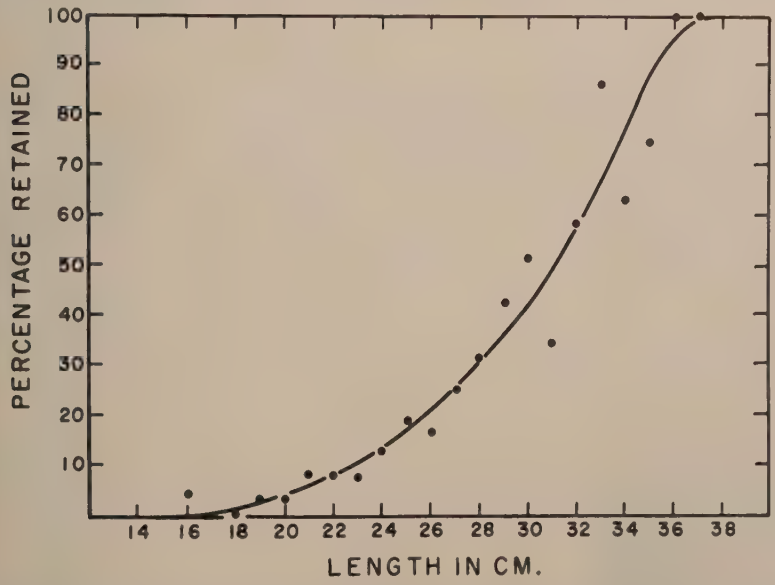

FIGURE 1.—Percentage of various sizes of ocean perch *(Sebastes marinus)* retained by a manila cod end of 132 mm mesh size. Based on experiments conducted by North Atlantic Fishery Investigations.

Inherent size selection comes about through the action of the trawl upon the fish entering the net and, being the most easily controlled, is the type of selection most important in management considerations. Of all the alterable properties of a trawl net the most easily controlled is the size of the mesh. An extensive series of experiments, mostly for the cod end of the net alone, has shown that meshes of trawls do release fish. Moreover, the escapement from a given mesh size has been shown to be inversely related to fish size, with proportionately more small than large fish escaping. The type of size selection occurring in otter trawls is illustrated in Figure 1 by a typical sigmoid selection curve. The size selectivity of a trawl is most commonly defined in terms of its 50 per cent point. This is the fish length which corresponds to the point on the curve at which half the fish entering the cod end are retained and half escape. The 50 per cent point usually increases in direct proportion to mesh size. This relationship is commonly defined by the SELECTION FACTOR, which is the quotient of 50 per cent point (cm.)/mesh size (cm.). Thus, the selection factor is an expression of the fish's capacity to escape. The selection factor varies from species to species and for a particular species varies with the conditions associated with its capture.

Some general knowledge of the type mentioned above was at one time sufficient to provide a basis for management programs. Precise definition of selection was not required because little was known of optimum rates of exploitation. The application of modern statistical methods to studies of fish populations has made precise estimation of optimum size at harvest possible. A demand for similarly precise determinations of gear selectivity has arisen therewith. This need for precision has required the expansion and elaboration of gear selection research in the North Atlantic. This paper will be concerned with the status of otter trawl selection research in the North Atlantic as it has been affected by recent developments.

The establishment of international commissions for management of certain North Atlantic fisheries during the past decade has encouraged an increase in size selection experiments with otter trawls. The resulting accumulation of information has increased our knowledge tremendously, but because of the precision required, disagreements among the results of many experiments have caused great concern. The seriousness of the differences moved the Permanent Commission, dealing with management problems in the Northeast Atlantic, to establish an *Ad Hoc* Committee to consider variations in results. The committee analyzed all available data in order to recommend certain selective standards for otter trawls. For a few species it was possible to choose a single selection factor. For many of the important species, however, the selection factor could be defined only in general terms. These results have been published by the Permanent Commission (1956).

The International Commission for Northwest Atlantic Fisheries (ICNAF), meanwhile, was meeting with similar problems. A summary of haddock selectivity data is shown in Figure 2 (from Graham, 1952) to illustrate the variations in results obtained for a single species of concern to ICNAF. The extent of differences is well demonstrated at a mesh size of approximately 3-3/4 inches where the 50 per cent point varies from 25 cm. to 43 cm. and the resulting selection factor varies from 2.6 to 4.5. Variations such as these render selection data difficult to apply to management programs.

The increasing concern over size selection problems on both sides of the Atlantic resulted in a meeting of gear selection experts from ICNAF, the Inter-

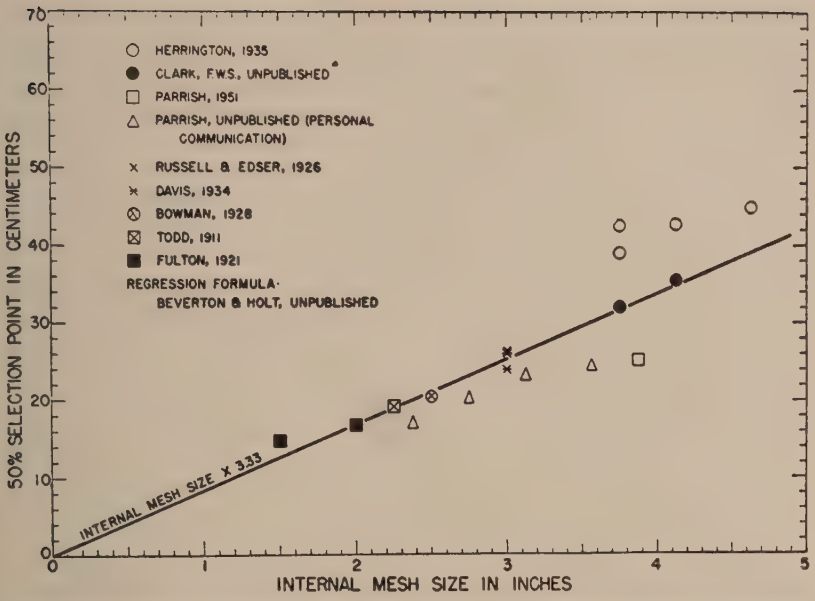

FIGURE 2.—Relation of size of mesh to 50 per cent retention size of haddock.

national Commission for the Exploration of the Sea (ICES), and the Food and Agriculture Organization of the United Nations (FAO) at Lisbon, May 27 to June 3, 1957. At the Joint Meeting, working parties were established to consider, among other matters, the factors of importance in the variations among gear selection results. The deliberations of the working parties demonstrated the complexity of the situation and indicated fruitful avenues of research that could be followed to provide a better understanding of gear selection processes. The results of this Joint Meeting[1] are used as a basis for the following discussion. The working parties were primarily concerned with results of otter trawl selection studies, the majority of which dealt with selection in the cod end.

It was brought out at the meeting that the variations in results can be attributed to either experimental causes or substantive causes. The experimental variations are those deriving from the manner of conducting the experiments and do not arise from real differences in the selective action of the trawls.

A number of experimental methods for determining the selection of sizes of fish by otter trawls are in use, each with its own peculiar sources of variation. The cover method involves the application of small mesh netting over various parts of the trawl to actually trap the escaping fish. A second method is the trouser trawl method, in which two cod ends of different mesh size are attached to the same net. The selectivity of the larger mesh is estimated by comparing the catches of the two cod ends. A third method, which may be called the replicate-haul method, involves the comparison of catches of two separate nets, towed

[1]The report of the Joint Meeting and the papers presented have not yet been published. The author has drawn freely upon the manuscripts in the following pages.

either in alternate series from one vessel or at the same time by different vessels.

The cover method provides the most precise results. Its use, however, is attended by a considerable amount of danger in that if improperly applied the cover can block the meshes and prevent the escapement of fish, thus giving erroneous results. Other disadvantages are that it may restrict the flow of water through the trawl, thereby altering the selective properties of the net, or may be seen by the fish and thereby discourage their escape, or may allow fish to return to the cod end after having once escaped. This method, although effective for the cod end if properly used, cannot easily be employed on the broad surfaces of the net or on its underside. In any event, the effect of the cover should be tested preliminary to the conduct of the experiment.

The other methods listed involve the comparison of the catch of different nets. The best of these is probably that of towing two nets simultaneously from boats fishing as near together as possible, or towing two trawls from the same vessel, as has been done with shrimp beam trawls and scallop drags. The problems inherent to this type of sampling arise from the non-random manner in which the fish are distributed (see Taylor, 1953). The trouser trawl method (two cod ends of different mesh sizes) is less useful because of the abnormality of its construction and a tendency for the two cod ends to catch different amounts of fish. The lowest of the selection values illustrated in Figure 2 were obtained with the cover method and the highest with the alternate tow and trouser methods; the correct values were found to lie in between.

Even with the experimental error accounted for, considerable variation in results may remain, owing to substantive factors. These are real differences which may be attributed to the type of trawl used and the conditions of its operation. The deliberations at the Joint Meeting brought out many important causes of substantive differences in selection research. These differences were shown to be associated with such things as length of tow, size of catch, type of twine used in the netting, and differences in the distribution of meshes of various sizes within the cod ends.

Varying the length of tow has been shown to alter the selection factor considerably. Experiments conducted to investigate the effect of length of tow on the escapement of haddock, for instance, show the selection factor to vary from 3.0 for 20 minute tows to 3.4 for 80 minute tows. Variations in size of catch of haddock in the cod end have been shown to alter the 50 per cent point by as much as eight cm, the higher 50 per cent point being associated with lower catches.

Comparison of results of many experiments have shown that the type of twine used in cod ends is an important factor. At a cod end mesh size of 60 mm, for example, silver hake *(Merluccius bilinearis)* have been shown to have a selection factor of approximately 2.5 for manila, 2.8 for cotton and 3.2 for nylon twine. The higher selection factors apparently result from more flexible twines.

Non-random distribution of mesh sizes in the cod end have been shown to be an important factor in haddock escapement. Meshes at the aft end of a cod end are stretched by the weight of the catch being hoisted aboard and will gradually increase in size over the meshes at the forward end as the cod end continues in use. Results from experiments with special covers have demonstrated that 70 to 90 per cent of cod end escapement takes place in the terminal five to six feet. Systematic differences in mesh size within the cod end must, therefore, be considered in order to interpret results properly. A demonstration of this effect is

provided by one experiment in which a nylon cod end having an average mesh size of approximately 123 mm was tested first in a normal position with the larger mesh aft, and then reversed to put the small mesh aft. In the normal position a selection factor of 3.5 was obtained; with the cod end reversed a selection factor of 3.1 was obtained.

In measuring the meshes of nets certain factors must be given consideration. Of particular importance are the extent to which the mesh is stretched and the particular dimension measured. It is evident that in comparing results of experiments the same dimensions of meshes must be compared. Less evident, but of equal importance, is the problem of stretching the mesh with a standard force. Meshes, of course, must be stretched to some extent in order to measure them accurately. Different instruments and methods may provide different amounts of stretch and, therefore, alter the resulting measurement.

When designing selection experiments the application of the results to the fishery must be thoroughly considered. The following questions are the sort which should be considered in applying results: Are the fish being damaged in escaping through the meshes? Is there an important amount of escapement through the forward parts of the trawl? Have results been obtained for the proper towing speed, twine type, catch size, and so forth? Have proper specifications of the gear been established? What systematic variation is there apt to be within distributions of meshes of given average size?

Another problem of importance involving the application of results is that concerning the type of relationship that exists between mesh size and fish escapement. The establishment of this relationship is necessary in order to predict, from experiments on a few mesh sizes, the size of the fish that will escape from any size of mesh. A simple linear relationship between mesh size and fish size has been accepted as being valid for various species. Certain recent experiments have shown, however, that this relationship cannot be applied to all

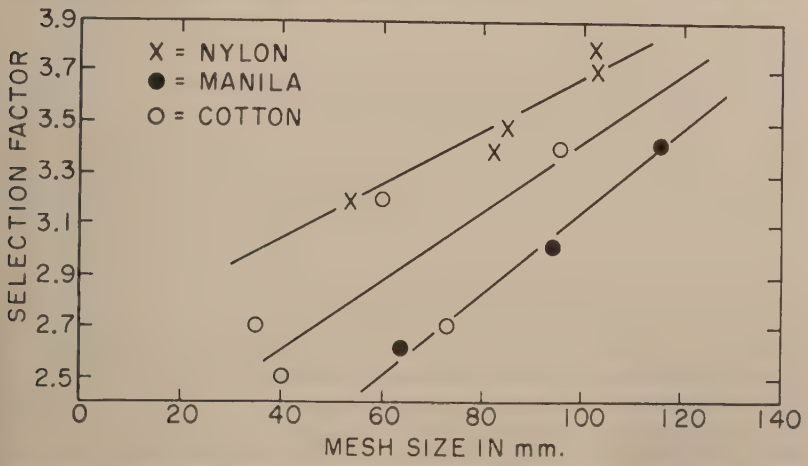

FIGURE 3.—Selection factor—mesh size relation for silver hake with nylon, manila, and cotton cod ends. Based on experiments conducted by North Atlantic Fishery Investigations.

cases. A non-linear relationship between the 50 per cent point and mesh size has been demonstrated for silver hake. This is shown in Figure 3 by the fact that the selection factor is not constant but changes with mesh size. Thus it cannot be accepted that the selection factor is constant over the range of mesh sizes for all species and the relationship must be considered separately for each case.

Research projects were recommended by the working parties of the Joint Meeting to provide solutions to specific problems. Some of this research is already yielding results. Certain studies with underwater television, for instance, which are underway at Woods Hole have provided valuable information on such things as: the action of cod end covers, the behavior of fish in the cod end at various towing speeds, the effect of additional layers of netting on top of the cod end (chafing gear), and the escapement patterns characteristic to various species.

The final test of the validity of selection experiments is, of course, the resulting effect upon the fishermen's catches. ICNAF, realizing the importance of testing the effect of its haddock regulation in this manner, required the maintenance of a licensed study fleet fishing with the small pre-regulation mesh nets as a control. Comparison of catches of this study group with boats using the regulation mesh confirmed the experimental results for haddock—both experimental results and study boat comparisons yielding a selection factor of 3.3.

Complex problems such as those arising from North Atlantic gear selection experiments, which are carried out by many nations, require close liaison between fishery researchers. The Joint Meeting of ICES, ICNAF and FAO by enabling workers from many nations to work together on their mutual problems, has provided a landmark in modern fishery research. Through close cooperation of researchers and the development of modern methods of research, such as underwater television, concepts are emerging to explain the puzzling variations in gear selection results.

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The Use of Radioisotopes as a Tag for Fish

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For many years fish have been marked or tagged for the purpose of determining rates of movement, migration routes, growth or mortality rates, or other life

history facts. Some of the methods used include tatooing, staining, fin clipping, inserting tags into the body cavity, or attaching some object externally such as a strap, a clip, a button, a dart, a colored string or a nylon line with an identification symbol. These methods have not always been entirely satisfactory as the tag may be difficult to apply, or may be lost after being attached, or may be difficult to recover. In searching for improved tagging methods fisheries biologists have sought new techniques and during the last few years this search has lead to a consideration of the use of radioisotopes. However, great use of radioisotopes for tagging fish has not been made, partly because other methods are obviously superior and partly because of a lack of understanding about obtaining and using radioisotopes. The objective of this paper is to discuss the use of radioisotopes as a method for tagging fish or shellfish and to answer some of the questions that have been asked about this problem.

Four of the questions follow: Is the use of radioisotopes practical? What are the hazards in handling radioisotopes? What isotope and what form of the isotope should be used? What are the procedures for obtaining isotopes?

A valuable list of reprints and articles about isotopes entitled, "Special Sources of Information on Isotopes," is available upon request from Isotopes Extension, Division of Civilian Application, U. S. Atomic Energy Commission, Oak Ridge, Tennessee.

To answer the first question it is evident that the radioisotopic method is practical if it is potentially equal to or better than other methods. To determine the relative values of the various tagging methods it is suggested that a tabulation of the tagging methods and of the factors that are important to the experiment be made. Factors to be considered include the ease of applying the tag, the effect of the tag upon the fish, the permanency of the tag, the ease of detecting the tag for recovery, the cost of tagging and recovery, the availability of supplies, etc. After scoring each method for all of the factors under consideration, the method with the highest score is likely to be the most practical.

Brief, accurate generalizations cannot be made about the practicality of using radioisotopes as tags for fish because there are only a few factors for comparison that are common to all experiments. However, since radioisotopes are not detectable by sight, it is obvious that a radioisotopic tag is not adapted to a tagging experiment where the recoveries of the tagged individuals are dependent upon visual inspection. Fish tagged with radioisotopes can be identified by means of radiation detection counters and under certain conditions, such as the rapid examination of a great number of individuals or with an animal that may shed an externally attached tag, the radioisotopic method may possibly be superior to the methods now in use.

The second question is, "What are the hazards in handling radioisotopes?" If radioisotopes are used to tag fish there are two possible, but not probable, sources of radiation exposure to man: (1) internal exposure from eating a fish tagged with a radioisotope and, (2) external exposure from working near the isotope. The regulations of the Food and Drug Administration do not allow the adulteration of food fish by any radioisotope and thereby the use of radioisotopes to tag fish that may be eaten by man is prohibited. This would eliminate consideration of condition (1) above. Information about the regulations of the Food and Drug Administration and the application of the regulations to a fish tagging program can be obtained from the Bureau of Program Planning, Food and Drug Administration, Washington 25, D. C. Dr. S. T. Grey is the present director.

Condition (2) above, "External exposure from working near the isotope," should present no particular problem if normal procedures for handling isotopes are followed, especially since only relatively small quantities of isotopes are required for tagging. In conclusion, it can be said that in compliance with Food and Drug Administration regulations and normal procedures for handling radioisotopes, the hazard to man of using radioisotopes as a tag for fish is negligible.

If, under special circumstances, permission is granted by the Food and Drug Administration for tagging fish, still another factor to be considered is the effect upon the fishing industry of an unfavorable public reaction to buying fish that may be radioactive. In 1954, in Japan, the public stopped buying tuna because some tuna were found to be radioactive and, as a consequence, the tuna industry was affected. Although the health hazard of the radioactive tuna was not known, the public assumed there was a hazard merely because the tuna were radioactive. We in Washington, D. C., are aware of the public concern about anything radioactive and an incident similar to that which occurred in Japan is to be considered within the realm of possibility.

The hazard to the fish of using radioisotopes is difficult to estimate because of the lack of experimental data on this subject. Since the rays emitted by a radioactive isotope are ionizing radiations and all ionizing radiations are damaging, there will be damage to the tissues of the fish. Therefore, the problem is partly that of deciding the degree of damage that can be accepted without affecting the fish to the extent of interfering with the experiment. The amount of radioactivity in the tag should be no greater than the amount necessary to detect the tag at the expected time of recovery, because the greater the amount, the greater the damage to the fish. Although specific information about the amount of radioactivity that can be tolerated by fish tissues is not at hand, it is known that a gold fish in which a bead of mixed fission products was implanted in the body cavity did live for several years and that during this time the fish was easily identified by a Geiger-Muller survey type counter. For this reason it is believed that implants into the body cavity of radioisotopes that can be detected for several years can be made without serious damage to the fish. However, much more information is needed on the relationship of dose to tissue damage in fish before a reliable prediction of the hazard to fish of using radioisotopes as tags can be made.

The third question is, "What isotope and what form of the isotope should be used?" The selection of an isotope depends, in part, upon the energy, the physical half-life, and the biological half-life of the isotope.

Radioisotopes emit three types of rays that vary in energy (penetrating ability) and half-life. The most penetrating are gamma rays. A radioisotope that emits gamma rays is desirable as a tag because there is a greater probability that the emissions from the tag will not be stopped before reaching the detector. Physical half-life is the time required for the rate of emission of rays from the radioisotope to be reduced by one-half. This value is a constant for any one isotope, but for different isotopes may vary from fractions of seconds to many years. A radioisotope with a relatively long half-life is desirable because a minimum amount of radioactivity in the tag at the time the fish is tagged will provide the maximum amount of radioactivity at the time of recovery. If the radioisotope is used in a form that is taken up by the tissues of the fish, then the total amount of uptake and the biological half-life of the isotope are additional factors to be considered. Biological half-life is a measure of the retention of an isotope in the tissue and is defined as the time required for elimination of one-half of the

total amount of the administered isotope. In resumé, the radioisotope used to tag fish should be a high energy, gamma emitter with a long half-life and, if used as a tag in a tissue, with a high uptake and long biological half-life.

Referring to the table "Isotopes Available in the United States and Canada Listed by Increasing Half-Life" on pages 89, 90 and 91 of the Radiological Health Handbook, a suitable isotope for tagging fish can be found by selecting a long half-life, high energy, gamma emitting isotope. A search of this table suggests that the three following isotopes would be especially suitable:

(1) 2.6 year Sodium 22 with a 1.8 Mev Beta and 1.3 Mev Gamma

(2) 5.3 year Cobalt 60 with a 1.3 Mev Gamma

(3) 33 year Cesium 137 with a 1.2 Mev Beta and 0.66 Mev Gamma

The form in which the isotope is used can be either liquid or solid. In the liquid form the isotope is either added to the water in which the fish lives or is fed to the fish in one way or another and part of the dose is expected to be absorbed in certain tissues of the fish. Where fish are tagged by these means there is no way of identifying individuals, a limitation to this method, and an objection that is equally valid for the fin clipping method.

Retention of the isotope in the body is usually only a small fraction of the amount administered and is usually concentrated in specific tissues. With reference to the three isotopes that were suggested as being suitable for tagging fish, Na^{22} could be expected to be found distributed through the tissues of most of the body, Co^{60} in the liver, and Cs^{137} in the muscle. Because Na has a relatively short biological half-life in many marine fishes, generally, Na would not be a suitable tag for fish tissues. Additional information on the distribution of Cobalt and Cesium in marine organisms is available in the reports by Dr. L. R. Donaldson, et al., at the Applied Fisheries Laboratory, University of Washington, Seattle; by Drs. H. V. Weiss and S. H. Cohn, et al., at the Naval Radiological Defense Laboratory, Hunters Point, San Francisco; and, by Dr. W. Chipman, et al., at the Radioisotopes Laboratory, Fish and Wildlife Service, Beaufort, North Carolina.

In the solid form isotopes can be obtained either as wire, pellets, or capsules. Use of isotopes in these forms is usually by insertion of the tag into the body cavity through an incision in the body wall. This method has no advantage over the magnetic tag method unless recovery of the tags is more efficient.

One possible advantage of the radioisotopic tag is that it can be detected in water, although in not very deep water. The intensity of the radiations decrease as the square of the distance from the source and are attenuated by the water. Even the gamma rays from a source of the size that would be used to tag fish could not be expected to penetrate more than a foot or so of water.

A convenient method of converting liquid isotopes to a solid form that can be used for implantation is to place the required amount of the isotope in a capsule, dry, and then seal. The capsule can then be used in the same manner as the wire or the pellets.

The last question to be answered is, "What are the procedures for obtaining isotopes?" In brief, the AEC regulations state that no person shall use byproduct materials except as authorized in a specific or general license.

In the Federal Register, Volume 21, Number 6, for January 11, 1956, under the heading "Title 10—Atomic Energy, Chapter 1—Atomic Energy Commission, part 30—Licensing of Byproduct Material" the general provision, licenses,

etc. are described. Byproduct materials are defined in 30.4(b) as follows:

> "Byproduct Material" means any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material;"

The types of licenses are explained in 30.20 "TYPES OF LICENSES."

> (a) Licenses for byproduct material are of two types: general and specific; the general licenses provided in 30.21 are effective without the filing of applications with the Commission or the issuance of licensing documents to particular persons. Specific licenses are issued to named person upon application filed pursuant to the regulations in this part."

Under the section on general licenses the use of radioisotopes in foods is prohibited, just as they are prohibited by the Food and Drug Administration regulations. Quoting from 30.21(3);

> (Persons) "(3) shall not add or direct the addition of, said scheduled items or quantities or any part thereof to any food, beverage, cosmetic, drug, or other product designed for ingestion or inhalation by, or application to a human being;"

The isotopes and the amount of each that are available under general license are listed in 30.72, schedule B*. For Cs^{137} and Co^{60}, the amount is one microcurie for material not as a sealed source and ten microcuries as a sealed source. Possession of ten individual quantities is allowed. A microcurie is 2.2×10^6 disintegrations per minute and about 10 microcuries is usually sufficient to tag one fish. Therefore the person who wanted to tag more than ten fish would need to obtain a "Specific License."

Applications for specific licenses shall be filed on form AEC 313, "Application For Byproduct Material License," with the United States Atomic Energy Commission, Post Office Box E, Oak Ridge, Tennessee: Attention: Isotopes Extension. The general requirements for issuance of a specific license are that "The Applicant's proposed equipment and facilities are adequate to protect health and minimize danger to life or property" and that "The Applicant is qualified by training and experience to use the material for the purpose requested, in such manner as to protect health and minimize danger to life or property; and further that the use will not cause any undue hazard to the health and safety of the public." Each application is reviewed individually and judgement as to the issuance of a license is based upon the specific conditions for which the isotopes are to be used. Application form AEC 313 and information on licensing, policies, procedures and related services can be obtained from, Mr. James R. Mason, Chief, Isotopes Extension, Division of Civilian Application, AEC, Washington, D. C.

Isotopes can be obtained from either AEC National Laboratories or from commercial suppliers. In general, the AEC is relinquishing their role as distributors of isotopes to the commercial suppliers as the suppliers become adequate to do the job. Catalogs, price lists, information on the availability of materials, and services, production and shipping schedules, and information on invoices and billing can be obtained by writing to the AEC National Laboratories and to the commercial suppliers. The list of "Suppliers of Isotope Materials and Services"

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*Na^{22} is now a processed cyclotron isotope and therefore not under general license.

that is also available from Mr. Mason's office at the address given above is very helpful for obtaining addresses of the AEC Laboratories and suppliers.

Among the services provided by the commercial suppliers is that of consultation and encapsulation of source material. For a fish tagging experiment it is likely that the suppliers could do anything from consultation, to encapsulation of the source, to the placing of the tag in the fish. This service may be of special interest if the fisheries biologist does not have the personnel or facilities for handling radioisotopes.

Processed cyclotron isotopes are not distributed by AEC Laboratories and are not subject to AEC license, but the commercial suppliers often require that an application form be filled out in order to make sure of the applicant's ability to handle radioisotopes. However, the Commission is continuing to perform, when it does not interfere with AEC programs, service irradiation in its cyclotrons. Processed cyclotron isotopes are available from the suppliers as indicated on the list, "Suppliers of Isotope Materials and Services." One of the processed cyclotron isotopes is Na^{22} but the price from a supplier in January 1956 was $200 per millicurie, which is a prohibitive price for a fish tagging experiment.

The cost of Co^{60} or Cs^{137} would be very much less. The actual cost of the chemical isotope ($2 per millicurie for $Co^{60}Cl_2$ and $0.10 for $Cs^{137}Cl$) would be only a few cents per tag, but the cost of shipping, handling and encapsulation, if necessary, would increase the cost several times.

Radioactive cobalt is also available (from Oak Ridge) in the form of wire 1/16″ in diameter, but the specific activity is so great that less than milligram amounts per tag would be needed. However, cobalt wire of the required specific activity can be prepared by service irradiation in a pile. By this method cobalt wire is placed in a cannister, which in turn, is placed in the pile and left there until the wire is of the required specific activity. The charge for this service, in the spring of 1957, was $15 per cannister for an exposure up to one week, and $45 per month for a longer exposure, plus the freight and handling charges.

Costs of isotopes change from time to time and are listed in many catalogues. An excellent compilation of the information on the cost and availability of radioisotopes from these catalogues can be found in the "Isotopic Index," which can be purchased for $3 per copy from the Scientific Equipment Company, Indianapolis 19, Indiana. If Co^{60} or Cs^{137} are used as the tag, the cost of the tags would be expected to be a minor part of the cost of the experiment.

Mention has not been made of the device to be used for detecting the tag at the time of recovery. Either a Geiger-Muller counter or a scintillation counter would be sufficient. This could be a portable hand carried Geiger-Muller counter or a more permanent type counter installed over a conveyor belt to scan fish as they move along the belt. A counter installed over a conveyor belt could be connected with an alarm system or with a device such as a trap door for the purpose of locating the tagged fish. Both a scintillation counter and Geiger-Muller counters, joined in series, have been used successfully to identify radioactive fish. The cost of counters would vary from $200-300 for a portable G-M counter to perhaps as much as $1500 for the larger and more sensitive permanently installed scintillation counter. Actual costs are available from the commercial suppliers of instruments listed on the report, "Suppliers of Isotope Materials and Services."

An estimate of the amount of Co^{60} that would be needed in a fish tag in order that the tag could be detected by a G-M counter arrangement was made by Mr.

Talkin of our Instruments Branch. This estimate was made in response to an inquiry about the use of radioisotopic tags in the Alaska herring fishery. For the matter of this discussion, consideration is not given to the food adulteration problem. It was assumed that a piece of Co^{60} wire is placed in the belly cavity and that recovery of the fish is from a conveyor belt or a flume as the fish move from the fishing vessel to the reduction plant.

Other factors in the calculations were as follows:

(1) 10 microcuries of Co^{60} in each tag

(2) G-M counters 30 cm. above the tagged fish

(3) 15 cm. of fish on top of the tag

(4) Fish were moving three feet per second

Under these conditions the radiations from the source that are received by the counters would be about twelve times background. Since a count of twice background would be sufficient to positively detect a tag, the 10 microcurie Co^{60} source can, theoretically, be detected adequately. The time that the tag was out was not used in the calculation but, since the half-life of Co^{60} is 5.3 years, the length of time out would not seriously effect the calculation.

In summary, it would appear that the present methods of tagging fish are generally more practical than the use of radioisotopes. Furthermore, fish tagging with radioisotopes are limited to non-food fishes by the regulations of the Food and Drug Administration and the general license regulations of the AEC. The hazard to the worker using radioisotopes for tagging fish is negligible with the normal care used in handling isotopes. Two isotopes, Co^{60} and Cs^{137} are suitable radioisotopes for fish tags in that they are inexpensive, have relatively long half-lives and are energetic gamma emitters. To use the quantities of isotopes necessary to carry on a tagging experiment a "Specific License" obtainable from the AEC is required.

INFORMATION SOURCES

"Special Sources of Information on Isotopes," Isotopes Extension, Division of Civilian Application, U. S. Atomic Energy Commission, Oak Ridge, Tennessee.

"Radiological Health Handbook" — U. S. Department of Health, Education and Welfare, U. S. Dept. of Commerce, Office of Technical Services, Washington 25, D. C., January, 1957, $3.75.

"Title 10 — Atomic Energy, Chapter 1 — Atomic Energy Commission, Part 30 — Licensing of Byproduct Material" — Federal Register, Volume 21, Number 6, for January 11, 1956.

"Application for Byproduct Material License," United States Atomic Energy Commission, P. O. Box E, Oak Ridge, Tennessee.

"Suppliers of Isotope Materials and Services," Mr. James R. Mason, Chief, Isotopes Extension, Division of Civilian Application, AEC, P. O. Box E, Oak Ridge, Tennessee.

"Isotope Index," Scientific Equipment Company, Indianapolis 19, Indiana.

Information on Food and Drug Administration regulations applicable to fish tagging experiments:

Dr. S. T. Grey, Director
The Bureau of Program Planning
Food and Drug Administration
Washington, D. C.

Information on licensing, policies, procedures and related services:
Mr. James R. Mason, Chief, Isotopes Extension
Division of Civilian Application
U. S. Atomic Energy Commission
P. O. Box E, Oak Ridge, Tennessee
(Washington 25, D. C. after January, 1958)

DISCUSSION

Biological Session

Discussion Leader: PAUL S. GALTSOFF

Discussion Panel: L. EUGENE CRONIN, GORDON FREDINE, PAUL THOMPSON, GEORGE ROUNSEFELL

Investigations of the Blue Crab

KENNETH DOWNES

Q. Anderson: In the discussion of larvae survival studies you said that you removed the debris from the water. Since the crab larvae in their natural habitat are subjected to great quantities of debris, why was this done?

A. Downes: Inasmuch as the crab larvae will be subjected to controlled laboratory conditions, a sand, shell, charcoal and glass wool filter system could best eliminate much of the undesirable debris from the incoming raw sea water.

The Role of River Basin Study in the Conservation of Fishery Resources

JAMES MCBROOM

Q. Hall: Has there been any effort on the part of the Federal government to control stream pollution?

A. McBroom: Not that I know of. Under the Blacknich Act to carry on federal aid for cleaning up pollution I believe that 45 million dollars was made available in the last session of Congress.

Plankton Studies and Fisheries

K. M. RAE

Q. Cronin: Would you comment on the limitations of predicting the year class of strength of fish from plankton collections?

A. Rae: The only practical prediction we can hope to make on this system—or for that matter on any system that entails measuring just one set of environmental conditions—is the statement that a particular year class will not be a good one. The alternate forecast, of course, is that it may be good or

it may be poor; in other words, it will be good providing no other factors spoil its potentialities. Whereas a single factor can limit survival, all conditions have to be about right to ensure good recruitment and we can only comment that one set of conditions was satisfactory.

Q. Thompson: Do you think the culture of aquatic organisms might offer more information about fisheries than other lines of research, such as studies of population dynamics?

A. Rae: I would not feel confident that it is more promising, but certainly think it should be done at the same time. The important step may be to get some of the animals from the open sea under our control in the laboratory. So far, practically all the experimental work has been done on littoral forms that seem hardier and easier to handle, but which for this very reason may not be comparable to the animals we really want to study in connection with fisheries.

Q. Fredine: Your studies on the movement of plankton and the fish which follow them are impressive. What about chemical studies not concerned with the physical movement of these animals and plants? Are studies on these phases keeping pace with physical studies?

A. Rae: It may be presumptuous to say so, but I don't think they are. The problem of course is to know what chemical parameters to measure; what constituents are most significant to the plants and animals. It seems to me that, although it holds great promise, marine biochemistry is only now really getting under way. We still know very little about the dissolved organics in sea water. For example, at the National Institute for Dairy Research in England, progress has been made just recently by studying the distribution of cobalamin in the sea. It seems that this potentially important vitamin can show considerable variations in its distribution both in space and time. It can be particularly abundant in the open Atlantic at the depth of the oxygen-minimum layer.

Rounsefell: (Comment) There are many productivity studies of deep layers of water going on today, but the fish are not in the bottom layer, and usually the material is converted before it becomes of value to the fish. If you would study zooplankton, you would measure what is directly available for the fish.

A. Rae: I am very much in favor of this, but although we are trying to think of some way of estimating zooplankton production rates, we are still far from doing so. We have a vague hope of approaching the problem through the lipids. There is suggestive evidence, by no means secure, that the poly-unsaturated fatty acids found in the marine animals all stem from the diatoms. If, by chance, this is so and we can consider stored fats as an indication of the excess of diet over requirement, then it might be possible to strike

some approximate balances between the turnover rates at various trophic levels right up to the fish.

Clark (Comment): I followed you in your story about the haddock to the point where the wind blows too hard and there are apt to be poor broods of haddock. But I am not clear just what the mechanism is that operates there.

A. Rae: The explanation we are using at the moment, for want of a better one, is that some factor which is necessary for the satisfactory hatching or survival of the haddock is carried to the spawning grounds from the Atlantic each year. The availability of this factor during the spawning season will depend on the pattern of mixing of Atlantic water within the North Sea, which in turn is dependant on the wind. It is important to note that period taken for wind in the correlations is the three months before the onset of spawning, so the wind must have taken its effect before the eggs are shed.

Oceanography and Fisheries

F. Koczy

Q. Thompson: How can collaboration between oceanographers and fishery biologists be improved?

A. Koczy: Oceanographers are sometimes so occupied by the approach of physical oceanography, that they forget to do some good for fishery biology. But, on the other hand, I think the biologist very often asks too much of an oceanographer. We are describing the ocean, and it is a very hard job. We have to study the ocean much more to get good answers. But, again, the fishery biologist should not ask a question which, from the beginning, can't be answered.

Q. Fredine: Is it reasonable for a biologist to ask an oceanographer if he could include studies on solar radiation and the effect of such radiation on marine plants and animals?

A. Koczy: I think it is and a lot of it has already been done, especially by LeGrand in France and in investigations by Jerlov and Bowden. I think light and sound are the two physical parameters which influence fish most directly. Both of them are directional.

Q. Rounsefell: In the last few years oceanographers have proven their usefulness in fishery investigation, but I want to know how we are going to process the tremendous body of data being produced so we can keep it current and make it useful for fisheries.

A. Koczy: It is very hard. But what we hope, perhaps, is that we can use electronic brains which will do the work of a hundred people.

Schaffer (Comment): I am a little more optimistic than Dr. Koczy about our ability to process the data. I don't foresee that we will continue to be appalled by its immense volume. We have to start being selective in its collection. Both in fishery biology

and in many fields of oceanography we are getting basic descriptions, but if we were to attempt to follow the meteorological method of attempting to get successive descriptive pictures, that is synoptic observations, this would be totally impossible financially. However, both the biologists and oceanographers can begin to look at certain critical processes in certain critical areas. Once we have an idea of the broad picture, we biologists can formulate some of the questions more specifically for the oceanographers. It is harder to ask significant questions than it is simply to go out and gather lots of data and then deplore the fact that these data are not thoroughly analyzed.

A. Koczy: That is completely right. We have to reduce the parameters to the important ones. This is the theme of our paper.

Size Selection Of Fish by Otter Trawls

John R. Clark

Q. Cronin: I remember in the Scottish movies of escapement of flatfish from a Danish seine. There was very little escapement except in the cod end. Is that typical of your experience with haddock?

A. Clark: For some species there is apparently a lot of escapement ahead of the cod end. Our experiments with haddock show that the escapement is mostly from the cod end and is not nearly so much from the forward part of the net. The escapement from the forward part of the net is confined to fish considerably smaller than those that escaped through the cod end. The very small sizes of haddock escape from the forward part of the net.

Q. Thompson: You have mixed fishery in New England. How does your mesh regulation work when the boats are catching several species?

A. Clark: In New England there are four important ground fish species caught: the silver hake, the redfish, the haddock and the flounder. The four and a half inch mesh, the minimum size allowed for haddock, is small enough so that all flounder are retained. But this is not the case with the redfish and silver hake, which are smaller. To be forced to use this mesh is a handicap for middle size trawlers that engage in fisheries where haddock may be the major species, and yet an important part of the catch may be silver hake or redfish. Fortunately, the redfish are distributed in much deeper depths than haddock, mostly over 70 fathoms, and there are few instances where the haddock and redfish are caught in the same tow. But boats may go out for redfish and instead fish for haddock if they happen to encounter them. We have tried to establish some procedure to avoid

this in the haddock fishery. One way was to specify that any fishing vessel fishing with small mesh cannot land on any one trip more than ten per cent of his catch in haddock. This was only partially successful and we discovered that we had to enlarge this exemption.

The Use of Radio Isotopes as a Tag for Marine Animals

A. H. Seymour

Q. Cronin: Do you think there is a possibility of marking very small fish and detecting the marks a year or two later?

A. Seymour: I would certainly say it is possible. You will have to accept certain limitations if you tag with this method. You will not be able to gather any information about the individual; you can only identify it within the group. It will take some experimentation to decide what isotope is going to be taken up in the greatest amount by the fish. With small fish you will have a limited amount of isotopes in the fish and will make the problem of identifying the fish at recovery time more difficult.

Q. Thompson: Aside from the attitude of the Food and Drug Administration, do you think the general public would accept the tagging of fish this way? Do you think it would be ethical to keep it a secret from the general public if we did it?

A. Seymour: I don't think we would want to keep it a secret from the public. The public is told that all radiation is damaging. They are told by the Atomic Energy Commission that the fallout is radioactive and the conclusion drawn is that we are damaged by fallout. The same thing would be true if the public were told that certain fish were radioactive. However, we have learned to live with radiation as we have learned to live with fire and with automobiles, all of which are hazards. In time the public will become educated and in a few years will not be very concerned about it. But at the present time, it is a real problem and there might be some repercussions that might bring financial loss to the fishing industry if radioisotopes were used prematurely in fish.

Q. Thompson: Are present radiation measurement methods sufficiently precise to detect radioactive fish in the fish houses and to calculate how many in a lot have been marked?

A. Seymour: Yes. When you measure radiation in the fish you are also measuring background radiation, that is, cosmic radiation, radiation from building materials such as granite or other stone and radiation from the earth, but with a relatively small source of radioisotopes in the fish you will be able to detect the tagged fishes over the backround. We have made a rough calculation on the amount of Cobalt 60 it would take for a herring for it to be detected as it came along a conveyor belt. It was assumed we were using a

Geiger counter at 30 centimeters, that there was six inches of fish above the tag and that the fish were moving at the rate of three feet per second. On these assumptions ten milicuries of Cobalt 60 would give a count of twelve times the background count. If you have twice the background count you can be sure of detecting the introduced material.

Q. Fredine: Do I understand that you believe that existing methods of tagging fish mechanically are probably more practical at the present time?

A. Seymour: Yes, in general it is correct. It has to be demonstrated that radioisotopes would be superior to other tagging methods.

Q. Fredine: Have you given any consideration to a combination of present tagging methods and radioisotopes? I can conceive of an external tag on a fish which might contain a bead or capsule of radioactive material which will aid in recovering it in commercial fishery activities or help to count fish going through a dam.

A. Seymour: By using a piece of cobalt wire or a pellet of radioactive materials in combination with a tag that had a number on it, you certainly might be able to improve present tagging methods if the radioactive tag can be detected more easily than a metal tag. In counting fish in water you must have the counter very close to the source. Even the most energetic gamma rays are stopped by water.

Q. Rounsefell: If we start to use radioactive tags do we have to train a great number of biologists to use radioactive substances?

A. Seymour: The AEC has regulations regarding the handling and use of isotopes. To qualify for a license for this they usually require that you have some experience in handling radioisotopes and this can only be obtained by going to school. There is another solution, and that is to use commercial suppliers of isotopes. They capsulate isotopes and insert them in the fish for you, if you ask. Actually the hazard is not great in handling the isotopes you would use for tagging of fish. You can have tags prepared in a form that will allow almost anyone to handle them and you will not have to have your biologists trained to handle isotopes.

Q. Clark: I see an analogy in the use of isotopes for marks with the problem involved in using dyes. Can you control the type or intensity of radiation in order to identify fish by lots? Is it possible to have certain combinations of an isotope so that you will know whether the material was introduced in the fish this month or last month, in this bay or that bay?

A. Seymour: If you are using the same isotope for all your marks there is no chance at all of doing this. An alternative would be to use isotopes of different elements and then this would be possible. But it certainly wouldn't be practical because then it would be necessary to analyze the fish tissue for the element, in addition to detecting the radiation. This is

expensive. Currently, the cost of making an analysis for strontium or barium runs $60 or $70 an element per sample.

Q. Idyll: There has been a lot of comment to the effect that this tag is no better than other tags. We are interested in the problem of tagging very small shrimp which will not carry an ordinary tag. It is important for us to remember that while radioisotope tags have limitations, we are grasping for something to mark animals for which we now lack any technique. The Fish and Wildlife Service people are about to engage in a field experiment to test the dyes on shrimp, fully recognizing that this has its limitations, but again seeking to fill a gap in our techniques. But if this doesn't work, then we are after something like radioactivity.

Are there radioactive materials which could be used to mark shrimp or other animals which could be identified after a reasonable length of time and which would not be harmful to a human being?

A. Seymour: Yes, there are isotopes which can be used which will not be a health hazard to those people eating these shrimp marked with them. Everyone who eats ordinary fish is eating some radioactivity because there is some in the muscle of all fish. It may be anywhere from one or two to as much as eight to ten per gram of tissue. So, because it is radioactive, it doesn't mean it is a health hazard. An official of the Food and Drug Administration has told me that the rules and regulations at this time would not permit adding any radioactive material to fish but said he would be interested in hearing any such proposal.

FRIDAY—NOVEMBER 15

Chairman—LAWRENCE W. STRASBURGER, *Food Technologist and Consultant, New Orleans, Louisiana*

Marine Fisheries and Fish Culture in the Caribbean

JOHN E. BARDACH*
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Marine Fisheries

A FIRST GLANCE at the Caribbean area reveals that there is much water and little land, about 1½ million square miles of the former and about 90 thousand square miles of the latter. Therefore, to the uninformed it would appear as if people who live in such an environment should have no difficulty in securing most, if not all, their proteins from the waters surrounding them. This, however, is not so. The reasons for the relatively low fish harvest from Caribbean waters are well known. First, there are those which stem from the economics of the region. The level of technology is low and we are dealing with an area in which many different nationalities practice varied kinds of administration. Secondly, there is the ecology of fish stocks to be considered. Most of the area has deep open water and the concentrations of fish in such waters are not dense. Also it is not known where these concentrations are or, for that matter, whether there are any. The marine fisheries of the Caribbean, with a few exceptions, are reef or bottom fisheries. This immediately changes the picture and makes the ratios of land and, therefore, of people to available fishing areas far less favorable. This does not apply to one large island complex, namely the Bahamas. There is some reason to hope, however, that the open waters of the Caribbean can and will be exploited much more fully in the future.

If we look at the world's scale fisheries, such as the menhaden fisheries of the Atlantic coast, the herring fisheries of the North Sea and the salmon fisheries and tuna fisheries of the Pacific Ocean, it appears that the concentrations of fish at the place of capture far exceed anything we can find even on the best populated reefs. It has been estimated that in such fish schools the capture is made from concentrations of about five to seven thousand pounds of fish per acre. Estimates of reef fish density have been made in two widely separated areas, one in Bermuda (Bardach, 1957) and the other by Odum and Odum (1955) in the Pacific. In both cases, the standing crop on shallow reefs was found to be surprisingly high, namely between four and five hundred pounds per acre. This includes all fishes and comprises many of non-harvestible size, so that a translation of these figures into yearly growth estimates of commercial fish would become far less favorable. Still, some of the best estimates available to date indicate that the fish growth on shallow reefs amounts to somewhere between 150 to 200 pounds a year per acre of isolated shallow reef, between 10 and 30 lbs. thereof may be larger carnivores. It should be added that these are rough estimates indeed, based on relatively few facts and many conjectures.

*Grateful acknowledgment is made to the Fisheries Committee of the Bermuda Trade Development Board for financial support in gathering background material for this study.

On second thought, however, dense fish populations are to be expected on shallow reefs because these are essentially self-sufficient communities which produce much organic matter in situ. Their productivity per unit area is considerably higher than in adjacent waters or, for that matter, of any open marine areas. Shallow reefs resemble shallow ponds because in both the incident radiation reaches the bottom and can be utilized by attached plants. In fresh water these are flowering plants or green algae; on the reef they are predominantly brown, but also red and some green algae.

There is another characteristic of reef fish stocks which prevents their methodic exploitation at a highly efficient level. In a reef environment highly mechanized methods such as scoops or trawls of any kind are not usable and bottom-based nets are also out of the question. Even if the Caribbean fisheries had boats to employ such tools they could not be used on the fishing grounds presently frequented. There are, in addition, as in all tropical environments, be it a rain forest or a marine area, a great number of species with a correspondingly small number of individuals, compared to a more northern climate. Thus, we are dealing with many different types of fishes of varying habits. This in itself makes a streamlining of operations difficult.

Other characteristics of reef fish stocks should also be considered here. The food chains are eminently demersal; very few, if any, reef fishes feed on plankton. Therefore, they are tied to the bottom very much more than other types of fish and are comparable to the true bottom fishes such as the soles, flounders and the halibut. But they cannot be trawled.

Tagging of fish in the shallow reef environment in Bermuda (Bardach, 1957a) revealed that a fairly sizeable proportion of the fish make any one reef area its permanent home. Some migrations back and forth between reefs or different reef areas occur, but the smaller the fish the more likely it is to have a relatively circumscribed home range.

Since all species of reef fishes are exploited over most of the Caribbean area and since at times, the individual fish in the catch are very small indeed, overfishing in a reef situation becomes a distinct possibility. Some preliminary investigations by the past fishery advisor for the Department of Agriculture and Fisheries of Jamaica on the Pedro Banks bear this out.

But to turn to the restrictions of technology rather than those of biology: At present Caribbean fishermen have access only to areas relatively close to shore; rarely do they reach reefs deeper than 30 fathoms. Table 1 reveals that an extension of boat range to the 100 fathom line would, indeed, benefit the reef fisheries of many Caribbean islands. The exploitation of depths to 100 fathoms becomes possible with inboard diesel powered launches and, therefore, one might employ a power take-off for the setting of traps and perhaps for the operation of automatic snapper reels. When boat improvement reaches this level a fairly untapped reef fish resource will become available.

Government sponsored fishery developments are to be found on almost all Caribbean islands. They concentrate on improving existing conditions. Where innovations are introduced simultaneously, this is done with caution rather than speed. Improved boats would not only open up further reef areas but they would also make pelagic fisheries possible. By pelagic fisheries one need not necessarily envisage trips of one to several weeks. Under existing conditions they would more likely turn out to be trips of one to several days. That there is considerable fisheries improvement to be gained by opening up a new pelagic environment in the Caribbean is clearly shown by the recent test fishing in

Haiti. Where bottom configuration could cause upwelling, stocks of tuna were encountered.

At the same time the successful catches strongly pointed to one of the most serious problems of Caribbean fisheries, namely that of distribution and marketing. Some kind of refrigeration is a necessity for holding over catches of a ton or more. Such facilities are almost nonexistent in most islands.

The answer here most likely lies not in deep freeze facilities, or at least not in their early establishment, but rather in small scale ice factories which could distribute ice to fishermen, as well as in some investigations of cheap insulating materials. Such installations are not as costly as deep freezes and there are several engineering concerns in France and Great Britian which have specialized in small scale ice plants.

Even this much change in marketing and distribution facilities is not immediately necessary to improve the present situation. The development of fishery cooperatives in Jamaica is a good case in point. Some regional fishing centers have developed there and more will develop under the present fisheries expansion plan. But it should be added that Jamaica is a cooperative-conscious island. Such regional fishing centers or cooperatives do not only facilitate distribution, they also are a great benefit to the fishermen in many other respects. The acquisition and repair of fishing tools and materials is made easier and the problem of education and improvement becomes much more manageable. The trend of development in the French island of Martinique bears this out very strongly.

Fish Culture

Fishery officers and their administrative superiors must search for all possible means of improving the protein supply to the people of their administrative units. It is not surprising, therefore, that in some islands they have experimented with the development of fish culture. A glance at Table 1 again reveals that such developments could become very important if fish culture can fulfill the promise it seems to hold. In other parts of the world harvests of two thousand pounds per acre and more have been realized. It is obvious that the development of fish culture becomes attractive in areas which have no sea fisheries or where the presently used marine fishing grounds, (the reefs in our case), hold little further promise. Fish culture means production of proteins with control of genetic stocks, the possibility of controlled nutrition as well as controlled harvest.

The islands in which fish culture has developed to some extent are Haiti, Jamaica and Trinidad. But even in these three islands fish culture is still in the government operated stage. It is inherent in the nature of a highly intensive food raising endeavor that some scientific and central control should perhaps never be relinquished.

In the government hatcheries of Haiti carp ponds have yielded two thousand pounds per acre and more. The situation is comparable in the tilapia ponds of Jamaica. The ultimate advantage of fish culture in the Caribbean would be in the scattering of many small ponds over the islands. Problems of marketing and distribution would, thus, be minimized.

In Haiti, the location of the oldest established fish cultural installations, such a situation has arisen in some districts. The regional agricultural agent and the fish culturists of the Department of Agriculture cooperate closely. Local residents with average holdings of less than an acre construct their own ponds, very frequently by manual labor. Most of them are not larger than 100 square

TABLE 1

COMPARISON OF LAND AND REEF FISHERY AREAS IN THE CARIBBEAN*

Island(s)	Population	Land square miles	30 fa. reef square miles	100 fa. reef square miles	People per sq. mile of reef 30 fa.	100 fa.
Bahamas	87,000	4,375	40,000+	53,400+	2.1	1.6
Cuba	6,000,000	44,164	20,000+	30,000+	300	200
Jamaica	1,500,000	4,411	765	1,600	2,000	940
Hispaniola	5,500,000	29,800	45,000	77,000	120	71
P. R. & Virgin Islands	2,500,000	3,635	2,500	4,250	1,000	590
St. Croix to Martinique	800,000	1,790	8,500	11,500	95	70
Dominica to Grenada	580,000	1,250	3,500	4,500	166	139
Trinidad & Tobago	700,000	1,980	4,000	11,000	173	63

*Land and Population data from West Indies and Caribbean Yearbook 1954/55 (Skinner & Co.; London EC2). Reef areas from U. S. Hydrographic Office Charts.

meters with a depth of 50 centimeters to one meter. Peasants receive the fish from central distribution centers and do little more than wait until they reach harvestable size. Without additional food, this takes place in seven to nine months. One has the impression that in the rural section of Léogane, where about 80 such ponds, recently stocked, are scattered over several square miles, a very great potential improvement in the protein supply has taken place.

There are, however, several reasons to subdue optimism. First of all, the yearly growth in such private ponds is far less than that realized under experimental conditions. It is difficult to estimate how much less, but to be realistic one should probably not expect over 500 pounds per acre per year. It was mentioned that the average peasant holding is less than an acre. In some cases, it is very much less and the establishment of even a small pond may become a problem because of the need for stomach filling crops regardless of nutritional value.

Three hundred ponds have been built in Jamaica since 1953, many of them by government workers. A projection of this development into the future suggests that it is not unlimited. First, there is the difficulty inherent in small land holdings by individual farmers. There are not too many of them, since most people who do agricultural work, are employed on plantations. The one or, at best, two-crop system of large plantations, often with absentee landlords, is not conducive to widespread fish pond construction either. In some regions, though not in Jamaica, there might even be problems of water supply.

These obstacles can be overcome but they will certainly restrain the rate of development beyond the present level. Furthermore, the servicing of over three thousand ponds, rather than three hundred, would involve so much work that no department of agriculture could assume this under the present, or even slightly improved future, conditions. It has already been mentioned that some control over the genetic stock is not only desirable but essential to keep up fish cultural yields and, therefore, central installations and distribution facilities would be taxed greatly by a substantial increase in ponds to be stocked.

If one were to assume the conservative yield of 500 pounds per acre and one acre ponds throughout, 150,000 lbs. of Jamaica pond fish might soon be harvested. But marketing of pond-grown fish, even on a restricted and local scale, has hardly begun. The ocean fisheries of the island yield probably close to 15 million pounds per year according to T. W. Burdon, of the Department of Agriculture and Fisheries at Kingston, Jamaica. A ten fold increase in ponds would be an ambitious, but not an impossible goal. Ponds would then produce about one tenth of what Jamaican marine fisheries yield now.

In Jamaica and Trinidad, where experimental tilapia culture has made fair strides, the trends of development are towards mono-sex culture (stocking of male fish only). This implies continuous restocking and it is difficult to imagine that local operators could quickly and easily learn and perform all the operations that are necessary for this advanced fish cultural method.

Some Caribbean islands, Trinidad, for example, have large fresh water or brackish water swamp areas. In these regions a more extensive type of fish culture can be practiced. Fish can be stocked and left to their own devices. If they are prolific enough, as seems to be the case with tilapia, chances are good that they will greatly augment the take of the professional fishermen who habitually harvest these areas. It is very probable that such developments could be extended to other islands as well.

Mr. Dudley Wiles, Fisheries Officer of Barbados, has given a very persuasive

and impassioned plea for developing a Caribbean fishery on a more or less regional scale at the meeting of the Gulf and Caribbean Fisheries Institute in 1956 (Wiles, 1957). His speech was an optimistic one. He suggested that the first step in fisheries improvement in the Caribbean was the realization of determined programs of fishery development. It is hard to decide whether such determined programs should arise at a very local or at a more regional level. The immediate problems are almost always local and it seems, therefore, most probable that the soundness of the local development plan is the key to the situation.

Another question inherent in such developments is that of their finance. From what has been said about the marine fisheries it appears that they must remain extremely versatile, even if the pelagic environment is opened up sooner than seems possible. Furthermore, in most cases fishermen will only own one boat rather than several. With the exception of high-cash crops like lobsters, the investment of outside capital is, therefore, not very likely to hold much economic promise for the investor. The need for fish on the island is so great that export is hardly feasible even if stocks and methods would permit this.

The most promising type of fishery development for any Caribbean island appears to be a gradual and slow change to better boats and gear with education of fishermen at the same time. Any improvement of storage and marketing conditions should at present be aimed at the relief of short-termed accumulations. These gluts occur seasonally in all Caribbean fisheries and are the most urgent problem of uneven distribution (flying fish in Barbados, jack and mackerel in Bermuda, to mention only a few). At the same time fresh and brackish water fish culture should be developed, like in Trinidad, Jamaica, and Haiti; Puerto Rico and Martinique especially, would benefit by such developments. It would be wrong, however, to place on fresh water fish culture the hope that it could do more than assist and augment the protein supply within a reasonably foreseeable future. The fact that Israel could establish a very intensive, highly successful fish culture in a few decades does not imply that the same thing can be done in the Caribbean. Some reasons for this have been given before.

The primary interest of workers engaged in the management and improvement of fisheries in the Caribbean is to increase and improve the extremely low protein supply of the 18 million people who inhabit this area. Many promising beginnings have been made, the most outstanding probably is the fisheries development of Barbados.

At the same time island populations increase at an alarming rate and with the expected improvement in health and sanitation this rate will go up rather than down. It is obvious, therefore, that even the most successful developments beyond present hope and belief, such as more than doubling existing harvests, can never satisfy the needs of the people of the Caribbean unless they and their leaders realize that the main and paramount problem in the area is not how to increase proteins but how to decrease population growth.

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New Research on the Relationship of Fats, Blood Cholesterol and Heart Disease

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In the past few years we have witnessed two rather extraordinary developments which have commanded much more than usual attention because of their possible significance in the health and well-being of major populations. The first was occasioned by reports of numerous investigators that cigarette smoking and lung cancer are closely associated. Despite all warnings—some quite strongly and even harshly worded—cigarette sales have continued to zoom upward, many, however, with assists from sundry filters.

The second began through the association of blood cholesterol with atherosclerosis. Our citizens have not shrugged off this latest warning. Instead, heart associations, doctors, and scientists have been deluged with inquiries as to the facts concerning diets. The reason for these distinctly opposed attitudes is not hard to find. In the first place, heart disease is the number one killer in this country and accounts for more than three and a half times as many deaths annually as all forms of cancer combined, while lung cancer is only one of these many forms. Thus, most American families have had some experience with coronary problems and, of course, the illness of the President two years ago placed the entire subject in sharp focus.

A few newspaper headlines are adequate indications of the widespread interest in the subject and the very considerable differences of opinion among the experts as to the exact relationship between dietary fats and coronary heart disease. "Heart Ills in U. S. Tied to Fat Food;" "Fat Strongly Condemned;" "Saturated Fats—Newest Dietary Whipping Boy?" "Are You Eating Your Way to a Heart Attack?;" "Dairy Foods Not Main Coronary Troublespot;" "Less Heart Disease on Protein Foods;" "Blood Fat Tied to Job Stress." It is only necessary to glance at these headlines to see that opinions have shifted rapidly and that there is lack of unanimity among the experts as to relationship of fat nutrition to blood cholesterol and coronary heart disease. A small group firmly advocates sharply reduced fat consumption, especially saturated fats, but the great majority of scientists urge moderate use of all dietary ingredients and express doubt that final analyses will justify any substantial overhauling of the more or less standard American diet.

Until about 1925 fats were not recognized as having any diet functions beyond their high density caloric values. Then, at first, certain essential fatty acids were looked upon as the only added nutritive components; as the years passed many new activities were discovered, among them improved palatability, in-

fluence on other nutrients, protection against capillary fragility, and influence on liver and blood cholesterol.

This latter brings us to the core of the subject. When all the fuss over the effects of fat on coronary disease started, cholesterol was chosen as the "goat" because, so far, no population with a low level of blood cholesterol has been found with a high instance of coronary heart disease and because further population surveys supported the claim that cholesterol levels were usually higher in persons with coronary heart diseases than with unaffected persons of the same age groups. These observations would be of no great significance if it were not for the fact that atherogenic deposits consist of cholesterol, fatty acids, and protein. There are two schools of thought as to why these arteries build up in specific areas, but there is definite agreement in present medical practice that hypercholesteremia is undesirable and that a return to a normal level is to be sought by all reasonable means.

Nonetheless, there are those who unyieldingly refuse to follow this theory and claim that the cholesterol level has no effect upon the development of atherosclerosis. This theory is actually supported by an eighteen year experiment with rats at the University of Southern California. Unfortunately, animal results cannot necessarily be translated to humans, but some scientists feel that lipid metabolism in rats does approximate that of humans. So, while atherogenic buildups can be definitely determined by examining rats from time to time, it is still not possible to make the same determinations with living human patients. Let us hope that the new project of the Fish and Wildlife Service at Hormel Institute will give us some direct information. Here arterial despositions of cholesterol will be followed through the use of radioactive tracers.

Because of the prominence attributed to cholesterol in cardio-vascular cases, it has been assumed by the uninitiated that the intake of food containing cholesterol should be markedly reduced. Commonest and richest natural sources of cholesterol in the standard American diet are dairy products and eggs, so any revolt against their use could have serious effects upon the national economy. Fortunately, we do have considerable knowledge as to the effects of cholesterol ingestions and synthesis.

We know, for instance, that cholesterol is rapidly synthesized in the body, but synthesis is not increased by fat feeding, unless there is an extreme advance in fat intake. Controlled experiments show that additions of as much as 30 grams of cholesterol in daily diets result in trivial increases in serum cholesterol, unless its feeding is also accompanied by substantial additional fat intake. Since the human diet rarely includes more than one gram of cholesterol per day, it is largely accepted that dietary cholesterol can be disregarded for all practical purposes. Therefore, attention should be concentrated elsewhere on the diet.

Since Americans obtain approximately 40 per cent of their calories in the form of fat, it was only natural that attention should be turned to the effects of fat on the serum cholesterol levels. Is there a direct relationship between the incidence of atherosclerosis and fat consumption? Also, are there other population studies which can be compared to our own? There are some indications that the austerity diets of the British Isles were responsible for a definite drop in cardiac mortality during the war years, despite the added stresses and strains. However, some researchers discount this experience and claim that the decline actually started before the reduction of fats in the British diet.

Another population study applies to Norway, where there was a marked drop

in mortality from heart disease by 1941. Again, some specialists discount this history because they say that rationing actually began in 1939 and that the fat shortage became acute in 1940. Nonetheless, the decline increased steadily until 1945 and then the trend reversed until the prewar figure was again reached in 1949. There is evidence in these figures that in a total population, at least, the effects of major changes in diet are not immediately felt.

Another wartime population study covered the Finnish people, who are looked upon as the most physically fit in the world and who are accustomed to a great deal of hard physical work. On the other hand, the Finns probably are not subject to the same pressures as apply to more urban populations, as in the United States or Japan. Furthermore, the medical service in Finland is of the highest order. Despite all these conditions, this extremely active rural population has a level of coronary disease equal to that of the United States. Their diets contain a lot of fats, but physical excercise and cold climate require a high level of energy. A possible clue is the type of fat consumed, because Finland utilizes a higher level of butter fats than almost any other country in the world.

The Japanese, in Japan, have a low level of coronary disease. When they move to Hawaii and change their eating habits accordingly, their coronary problems increase; when they move to California, where they gradually acquire complete American eating habits, coronary deaths among them take the lead as with our own population.

Finally, it is argued that Eskimos consume very large quantities of fat, yet have a very low incidence of coronary disease. At best, the Eskimos are not a good subject population to compare with the Finnish, Norwegian, Japanese, Italian, or American people because they live an unusual and primitive kind of life, their total number is small and scattered over considerable areas, and by no stretch of the imagination could their normal diet be looked upon as comparable to ours. In passing, however, it is worth noting that Eskimos do consume considerable fats almost exclusively from fish and seals, and that the protein level of their diet is reported as extraordinarily high—45 per cent as against 14 per cent in the average American diet.

Where does this lead us? It appears that fat *per se* cannot be labeled as the culprit. Under strict dietary conditions, rather than with patients enjoying normal variety in their diets, cholesterol levels have been increased in the blood by the addition of animal fats and have been decreased by the addition of vegetable fats. Decreases in cholesterol levels have been induced by the replacement of animal fats by vegetable fats. So, it appears that the kind of fat may be of vital consequence. According to one group of workers the mean degree of unsaturation in the fat, rather than the content of any specific unsaturated fatty acid, determines the cholesterol level in the blood. In other words, a judicious blending of fats is undoubtedly desirable, especially for people who have hereditary or other inclinations toward atherosclerosis.

It is well established that the addition of highly unsaturated fats for the purpose of offsetting detrimental effects of saturated fats is inadvisable because of the high caloric value of such a diet. Also, experiments have shown that unsaturated fats must be added at levels of two to three times those of the saturated materials if they are to be at all effective.

At this point let us take a look at some of the fats and oils which appear most commonly in the human diet and explore briefly the fatty acids supplied by them (Table 1). Unsaturated fatty acids are shown as percentages of total fatty

UNSATURATED FATTY ACID COMPOSITION OF SOME MARINE, ANIMAL, AND VEGETABLE OILS*

FATTY ACIDS	Characteristics				Per cent of Total Fatty Acid Composition																	
					Marine Oils							Animal and Vegetable Oils										
	No. Carbon atoms	No. C=C double bonds	Acid number	Iodine value	Cod liver	Herring	Menhaden	Pilchard	Salmon	Sardine	Sperm-body	Butter fat	Coconut	Corn	Cottonseed	Lard	Linseed	Olive	Palm	Peanut	Safflower	Soyabean	Tallow-beef
Lauroleic	12	1	285	128								0.4											
Myristoleic	14	1	248	112	0.2			0.1	0.1	0.1	4.0	1.6											
Palmitoleic	16	1	221	99.8	20.0	18.0	17.0	11.8	10.6	11.8	26.5	4.0											
Oleic	18	1	198	89.8	29.1	9.0	27.0	6.2	17.1	10.0	37.0	29.5	6.0	46.0	24.7	48.7	21.0	82.8	43.0	60.0	26.4	28.0	44.4
Gadoleic	20	1	180	81.7							19.0												
Erucic	22	1	166	75.0							1.0												
Linoleic	18	2	200	181		13.0		11.5	11.5	15.0		3.6	2.5	42.3	49.7	12.2	17.4	7.2	9.5	21.0	67.3	52.6	2.2
Linolenic	18	3	201	274												0.7	50.6				0.2	8.0	0.4
Arachidonic	20	4	185	334	25.4	20.0	20.0	17.9	23.5	22.0						0.4	0.1					0.05	0.1
Clupanodonic	22	5	169	384	9.6	25.0	12.0	13.8	16.2	19.0													
Tetracosa-polyenoic	24	?	—	—				15.2															
TOTAL					84.3	85.0	76.0	76.5	79.0	77.9	87.5	39.1	8.5	88.3	74.4	62.0	89.1	90.0	52.5	81.0	93.9	88.7	47.1

*Data taken from a chart prepared by the Technical Products Division of the E. F. Drew & Company, Inc., New York 10, New York.

acid composition. Coconut oil is at the bottom of the list, followed by butter fat, beef tallow, palm oil, and lard, and in each of these instances the level of polyunsaturated linoleic acid is extremely low, while oleic acid, which experimentally has had little effect on blood cholesterol levels, predominates. In general, the marine oils are much more highly fortified with polyunsaturates. In a six year controlled experiment, sardine oil showed to no better advantage than the oils containing predominantly linoleic acid. Therefore, there was apparently no effect beyond the two double bonds. Nonetheless, there has recently been an increasing interest in arachidonic acid because there is considerable evidence that it is the biologically active form in which the unsaturated fatty acids influence cholesterol metabolism. There is still other evidence that arachidonic acid may be a component of an important enzyme system in the heart muscle. With this constantly expanding interest in the polyunsaturated fatty acids, which occur naturally in fish oils, we have reason to be highly pleased with the basic research supported by Fish and Wildlife Service under the Saltonstall-Kennedy program.

A word of warning is necessary here. It is not suggested that we should urge the replacement of any one kind of fat or oil for another at this stage of research. However, fish and fish oil producers should encourage every possible study towards greater enlightenment in the field of coronary disease. We are apparently keeping good pace with the field and we should surely maintain that position. Possibly more than ever before. fish should presently be sold on the basis of its established nutritive merits. We know that most of the more common fish contain a low level of fat and provide many of the essentials of an adequate, healthful diet, such as proteins, minerals, and vitamins. Because fish oils, when they are present, supply highly unsaturated fatty acids we can be confident that they do not contribute detrimentally towards atherosclerosis or other coronary diseases. Surely a nice fish fillet or steak is a more constructive addition to the diet than one of the several special products which have recently appeared on the market for the specific purpose of reducing blood cholesterol.

Another recent medical finding needs mention here. One of these has to do with thrombo-embolism. Is has been noted that in Southeast Asia particularly, where diets have been relatively low in fats historically, clotting complications following surgery are rare occurrences by comparison with the experience here in the U.S.A. and in Europe. During the last war the relationship of fats in the diet to clotting following major surgery was clearly demonstrated in Norway. When the fat level of the Norwegian diet dropped to its lowest point the problem of thrombo-embolism declined to less than one-third of the pre-war level. It has now been shown that a heavy meal, containing considerable fat, often induces a state of hyper-coagulability for a period of some hours. Therefore, thrombosis surely should be explored in connection with all dietary fat studies as a parallel to atherosclerosis.

Thus, there are those who do not go along with the concept that a high level of serum cholesterol has anything to do with developments of atherosclerosis. There are others who believe that the problem is not so much one of high cholesterol level as it is a lack of essential fatty acids. However, it is safe to say, apparently, that the problem is a complex of relationships involving the body waste, obesity, hormonal balance, general composition of the diet (with special emphasis upon the quantity and quality of the proteins), age, sex, racial origin, and various kinds of physical and emotional stress.

Early in November, 1957, a report was presented to the American Heart

Association at Chicago by a San Francisco research laboratory. The findings of Drs. Rosenman and Friedman were based upon studies with 42 male tax accountants. Blood cholesterol samplings were taken during three periods of stress and three of relative inactivity. The results, which showed maximum blood cholesterol under stress in 83 per cent of the group and minimum counts during lulls for 75 per cent of the group, are looked upon as certain evidence of the importance of mental tension on coronary disease. "Even more striking was the highly significant acceleration of blood clotting time." Under stress the average time was five minutes as against 9.4 minutes when the accountants were under minimum stress. This report also bears out once again the close relationship between thrombo-embolism and blood cholesterol levels.

There are those who contend that fat consumption in this country has not gained in the past thirty to fifty years—the change is rather one of impossible calculations. It will also be argued that coronary disease has not increased—we simply have better statistics and more accurate knowledge as to causes of death. Whether gaining or not, atherosclerosis is still the long leader in the cause of death in this country and among other populations. It behooves all of us, therefore, to avoid creating public hysteria and to encourage continued orderly research now so well started.

Weather and Caribbean Fisheries Development

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THE WEATHER is one of the great controlling factors in marine fisheries commercial production. Weather is made up of a combination of conditions of air, temperature, moisture, wind, sky and cloud formations at any given time and place. For the purpose of this paper we will apply the term "weather" mainly to wind and its effect on sea conditions in fisheries development. Winds and choppy seas are assets under some circumstances in fishing gear operation. For fishing vessel operations such conditions are another matter. They can result in anything from a mere inconvenience to a genuine hazard for small vessels. In fact, it has been said that the sea is almost always rough for small ships. This axiom holds true in the Caribbean Sea as in other open waters for fishing vessels, which most generally fall into the class of small ships.

In recent years there has been considerable fishery developmental activity in the Caribbean, where small ships play a part. United States Government exploratory fishing vessels have been working with some success in the area to evaluate the potentials of tuna and other latent offshore fisheries. Japanese vessels, under various types of cooperative arrangements with some of the local Caribbean governments, are also exploring the Caribbean and adjacent waters. In addition to this, substantial local effort is being placed on pushing the historically inshore fisheries outward from Island shores. A large tuna cannery has been established at Ponce, Puerto Rico. Most of the raw material used at this cannery is derived at present from the Pacific. However, this installation has perhaps given greater confidence to a developing market for Caribbean produc-

tion. With interest mounting in fishery development in the open Caribbean, some knowledge of the weather and its effect on sea conditions seems valuable for those who venture their capital there.

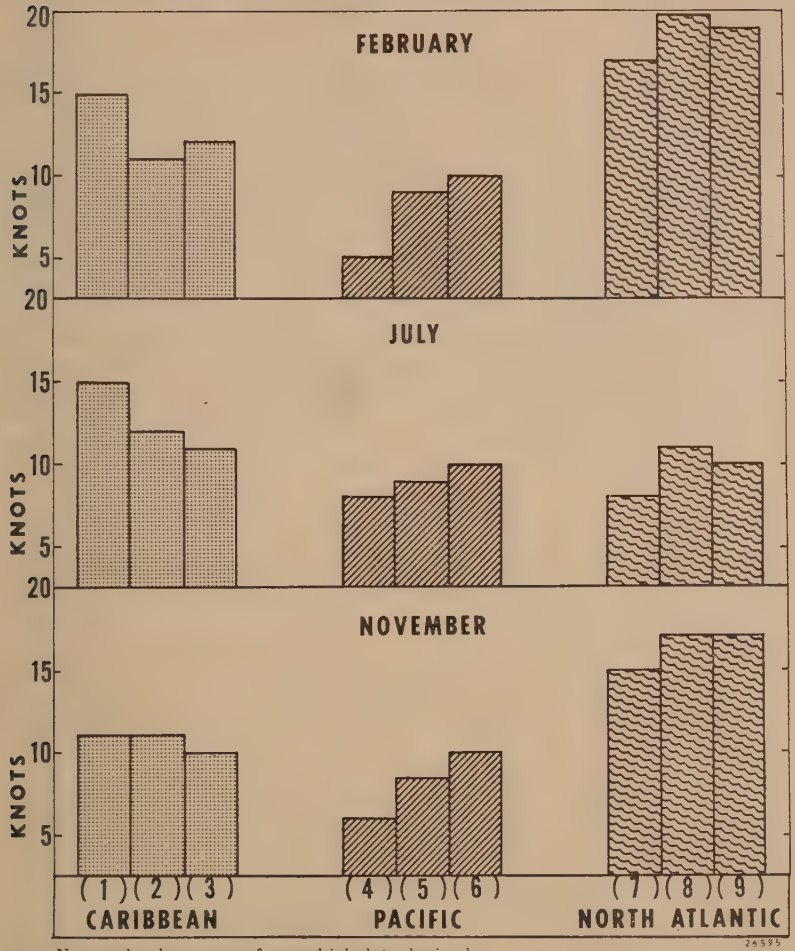
In general, the Caribbean is blessed with clear weather. Fog, sleet, snow, and overcast of any consequence are practically unknown in this sub-tropical area. Because of the pleasant climate which prevails, and because of the many glamorous descriptions written in travel brochures and other publications, there is some tendency to think of the Caribbean as a large and placid blue-water ocean lake. Although this is close to being a fact, insofar as most elements of the weather are concerned, there are wind conditions which should be recognized for their effect on fishery operations. The significance of so doing can be readily understood from accounts of difficult passages from the Panama Canal eastward across the Caribbean as experienced by some Pacific tuna vessels in delivering fish to the cannery at Puerto Rico. These craft, among the largest in our fishing fleet, are fairly able and are designed to cope with usual sea conditions, even when loaded. Some of these vessels have encountered heavy going off the Gulf of Darien in the southwestern Caribbean. One freezer vessel with 600 tons of tuna aboard was lost during a February gale in 1955 (Anonymous, 1955). These are extreme conditions. Nevertheless, they point up the need for caution during certain parts of the year and in certain sections when winter gales or northers are apt to set in rapidly and in the late summer when hurricanes develop. At times there also are the usual thunder squalls found in the lower latitudes, but these, even though violent, are of short duration. On the other hand, April and May are the most tranquil months in all parts of the West Indies when the finest weather and smoothest seas are experienced (Anonymous, 1951).

As well as it may be to have an awareness of such conditions, our principal interest with respect to fisheries is in the average kind of weather likely to be found in the area throughout the year. The northeast trade wind is the dominant factor from this standpoint. In spite of its name, the northeast trade normally blows more from an easterly direction, even at times from the southeast in some parts of the Caribbean. This wind is very dependable at all seasons over the passages from Puerto Rico to Jamaica, but sometimes is interrupted by northerly winds in the cooler months and briefly though violently disturbed by tropical cyclones which pass through during the warmer seasons, as mentioned earlier herein (Anonymous, 1951).

On the coast of the large islands at places most exposed to the direct flow of the trade from the open sea, the land and sea breeze influence is seldom of sufficient strength to overpower the prevailing trade wind. However, it becomes evident in a very noticeable daily variation of wind force which appears as a considerable increase in wind velocity at mid-day and a decrease during the night. This may account for the belief that the trade wind is stronger in the West Indies than in most parts of the world (Anonymous, 1951).

The effect of these easterly winds is a choppy sea that sets up during the daylight hours, particularly around mid-day and afternoon. These effects, of course, vary, depending upon the direction of the current. In such places as the Gulf of Darien, where there are currents contrary to the general westerly flow of Caribbean waters, confused seas can build up that make fishing from a small vessel next to impossible and sometimes even dangerous. There is testimony on this from personal experience while bound from Colon, Panama to Trinidad on an eighty-five-foot purse seiner. At that time the windows in the pilot house of the

Average Wind Velocities Certain Months



Numerals show areas from which data derived:

1 - East of Panama
2 - South of Puerto Rico
3 - West of Grenada
4 - Galapagos Is.
5 - Clipperton I.
6 - Guadelupe I.
7 - Georges Bank
8 - Sable I.
9 - Grand Bank

vessel were stove-in by heavy seas and only fifty-two miles were logged in the first twenty-four hours off the Gulf of Darien.

However, in most regions, although seas begin to make up to some extent with the freshening of the winds every day, the waves usually run in a more uniform direction. The sea is not rough enough to be dangerous for a small craft but, unless a vessel has good sea-keeping qualities, the handling of fishing gear is awkward, time-consuming and frequently not too productive. This is a definite

consideration to be reckoned with in the type of fishing that requires the vessel to be hove-to while setting and hauling back gear, but not so much in trolling operations.

In fact, one can look for medium seas (three to eight feet) more than fifty per cent of the time even in August in the 10-20 degree northern latitudinal belt in which the Caribbean lies (Bigelow and Edmondson, 1947). This accords with the average trade wind velocity of 12-16 knots.

This means that small craft fishing the open Caribbean should be well enough founded to operate in seas of something between three and eight feet in height or otherwise lose perhaps half of their fishing time. On the other hand, the occurrence of high seas (over eight feet) is fairly infrequent (zero to eight per cent of the time) during the same month. The balance of the time, of course, represents a substantial percentage of low-sea days (zero to three feet)—a delight to any fisherman.

High seas are somewhat more frequent in the Caribbean during January and February than in August, which corresponds to the fact that the trades average slightly stronger in the winter than in the summer. Even so, the number of low seas is about the same in one season as in the other. The sea, too, is usually smoothest under the shelter of the Lesser Antilles, of the Virgin Islands, Puerto Rico, Hispaniola, Jamaica and Cuba and roughest in the down-wind parts of the Caribbean off the coast of Colombia, Costa Rica, and Nicaragua, in winter as well as summer, which is to be expected since the trades here have an effective fetch of 350 to 375 miles (Bigelow and Edmondson, 1947).

Some idea of fishing weather in the open Caribbean can be gained by comparisons with wind conditions in other fishing areas, as shown in chart on page 145. (Anonymous, 1945).

The areas on the chart for which data were analyzed were selected purposely for comparison of the Caribbean with certain well known commercial fishing areas. California tuna vessels operate in the general region indicated for the Pacific. New England groundfish trawlers work in the areas chosen in the North Atlantic.

There are at least three rather interesting things shown by the data in this chart on wind velocities. First, it is apparent that the Caribbean average wind velocity in each of the months considered is rather uniform in comparison with the North Atlantic areas chosen, but not as uniform as in the particular areas on the Pacific side. Secondly, the average velocity in the Caribbean is substantially greater than in the Pacific, where most of the commercial tuna vessels ply their trade. Thirdly, it is somewhat surprising that in the month of July—representing the summer period—the Caribbean wind velocities, especially in the western parts, are greater than in the North Atlantic areas from which data were taken.

To get an indication of the frequency of occurrence of Caribbean wind velocities in the higher ranges, additional analysis has been made from the Pilot Chart for the month of July. Off Panama, 67 per cent of the time winds ranged from 16-18 knots; off Puerto Rico, 78 per cent of the time, 18 knots; and off Grenada, 81 per cent of the time, 11-12 knots. In the same month, in the North Atlantic—rather conventionally assumed to be rougher—54 per cent of the observed wind velocities were between 8-13 knots. It should be emphasized here that no sweeping statistical analyses have been made. The data are sufficient, nevertheless, to show that the average every-day Caribbean wind conditions,

even in summer, can be inconvenient for small boats—unless properly designed —and a handicap to their gear-handling operations.

There is an old adage, reminding us that it's an ill wind that blows no one some good. This can be aptly fitted to the Caribbean, because the winds and choppy seas, which have been mentioned as bothersome in small-vessel operations, actually are benefical in fishing longline gear. From experience so far, it seems most likely that longline gear will be the principal, and probably the most productive device used in the open Caribbean for the development of fisheries for tuna and tuna-like species. There is rather good reason to believe that this gear fishes far more effectively at times when there is surface wave action.

On the basis of preliminary examination of results of 175 longline sets, made in the Gulf and Caribbean during exploration by the vessel OREGON, catches in moderate seas were 35 per cent better than in calm seas. Catches in heavy seas were 23 per cent better than in calm seas. We are not certain as to the reasons for this. Perhaps the surface waves create enough longline movement so that the baits are more active and, therefore, more attractive to the fish; perhaps it is the agitation of the water which churns up the general food supply. One thing we know for certain is that the wind and the waves are factors to be considered in Caribbean fishery development.

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The Lobster Fishery of Puerto Rico

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Introduction

THE SPINY LOBSTER, *Panulirus argus* Latreille, has a considerable local importance to both the commercial and sport fisheries of Puerto Rico. The commercial landings are worth around $100,000 per year to the fishermen, and according to Erdman and Zalduondo (1956), records of 37 spearfishing trips collected at the port of Joyuda showed that this species represented 43 per cent of the catch by number and 16 per cent of the catch by weight of the sport spearfishermen landings. The increasing demand for this item has made necessary its importation from other countries.

This paper is the result of a study undertaken since 1955 by the Division of Forests, Fishery and Wildlife of the Department of Agriculture and Commerce of Puerto Rico for the purpose of ensuring a better management of the fishery, and of furnishing reliable information to the inquiries which this agency receives both locally and from abroad.

Description of the Fishery

The spiny lobster fishery of Puerto Rico has a comparatively recent origin, having attained economic importance around 1947. From that year on, the production increased considerably up to 1951. A probable decrease took place after that date, as shown by evidence found at Puerto Real and Culebra, the two most important production centers. This is probably due to the natural fluctuation in a virgin area.

The spiny lobster is fished around the whole Island of Puerto Rico, but the most important fishing grounds are located on the western and eastern coasts, which have a larger shallow area. (See Fig. 1).

FIGURE 1. Outline map of Puerto Rico showing fishing ports and extent of fishing grounds.

The boats employed in this fishery are of wooden construction. They are locally manufactured, native timbers with natural bend being used for stems, ribs and sterns, and only wood for planking being imported. They are strongly built and well kept. Three types of boats are used: rowboats, sailboats and motorboats. The rowboats are of the dory type, most of them flat bottomed, ranging in length from 10 to 18 feet. The sailboats are decked, usually having a live well for holding the lobsters. They are sloop-rigged vessels ranging in length from 15 to 35 feet. Few motorboats are employed at present, but their number is increasing. There are two types in use, a keeled skiff having an outboard motor of 5 to 10 HP, and equipped with a live well, and a decked and bigger boat of the class generally used for harbor work. This is not specially adapted for fishing, but it can cover long distances in less time and is not so dependent on the weather conditions.

Several types of fishing gear are employed, of which traps are the most im-

portant. There are two types of traps, wire and wooden traps. The wire trap, locally known as "nasa," is in general use throughout the Island. It is made in the shape of a broad arrowhead, and it varies in length from three to six feet, being three feet wide and eighteen inches high. It consists of a wooden framework made of mangrove wood, covered with galvanized chicken wire. The complete apparatus, consisting of the wire trap equipped with buoy lines and floats, has an average cost of $7.50. This trap lasts around twelve months. The wooden trap or "cajón" is of a type modified from that used in Florida, being rectangular or square in shape, but tapering from base to top. It has a base of approximately three to four square feet, and a height of two feet. It consists of a framework of mangrove wood covered with bamboo laths spaced 1½ to 2 inches apart. It has an average cost of $3.00, including the buoy line and the floats. It lasts around eight months, and except for a few fish which have no commercial value, its catch consists exclusively of lobsters. Both the wire and the wooden trap are fished at depths from 3 to 20 fathoms.

According to Iñigo (1952) there was a total of 223 fishermen employed in the spiny lobster fishery in 1951. This number has probably remained more or less the same since then.

The fishermen bring in their catch alive by means of live wells, or in damp jute sacks. The wholesalers usually have agents in each port who purchase the lobsters and keep them alive in live cars until an adequate amount for shipment is available. The lobsters can remain there for weeks provided that they are not too crowded and that they are provided with enough food. When the time comes they are transported alive in damp burlap sacks to the wholesaler's establishment, where they are sold to retailers or to hotels and restaurants, alive or frozen, either raw or boiled. At present lobsters are not canned or processed in any other form. After being boiled, the entire animal is sold frozen, since the meat from the head and legs is also used by the consumers for the preparation of salads and soups.

Production Statistics

The estimation of the true economic importance of this fishery, and the determination of trends within its production must be based on an efficient system of collecting fishery statistics. Such a system has not been employed in any of the Puerto Rican fisheries, and its establishment would take some time in a fishery like this, which is based on small catches landed at different localities and sold through different dealers who do not keep any books most of the time. The only information available is that furnished by Iñigo (op. cit.) in his survey of the fisheries in 1951, and that collected recently at Culebra, Puerto Real and La Parguera for the purpose of this work. Most of the data were collected at the fishing center of Culebra Island, because, besides being the second in production, its landings are centralized, a fact which facilitates the taking of information. Since the development of this center started in 1948, the data available should be sufficient for its appraisal.

Iñigo reported the catch of the whole lobster fishery of Puerto Rico during 1951 to amount to 466,760 pounds, valued at $87,333 to the fishermen. According to this author, the figure reflects the sharp increase in lobster production which had taken place since 1947. There is evidence to support the idea that there has been some decline in the catch since 1951, even though its value

might have remained more or less the same due to the increase in price. The present price per pound paid to the fishermen ranges from $0.25 to $0.35, and there are even some dealers who have paid as much as $0.40.

The demand for this product has increased and, as can be observed in Table 1, there has been a rise in the importations in the last few years.

TABLE 1

IMPORTS OF LOBSTERS (NOT CANNED) INTO PUERTO RICO
1950-51, 1954-55, and 1955-56.

Year	*Country*	*Pounds*	*Value*
1950-51	Netherland Antilles	2,923	$ 1,150
	French West Indies	880	308
	Total	3,803	$ 1,458
1954-55	Ecuador	5,714	$ 1,851
1955-56	Ecuador	1,890	$ 1,253
	Mexico	493	304
	Cuba	13,309	4,730
	Leeward & Windward Islands	2,060	534
	Total	17,752	$ 6,820

Fluctuations in the lobster production of the banks of Culebra Island are possibly caused both by biological and non-biological factors. As a general rule, the peaks of production seem to occur around the months of November and December during the winter, and around the month of May during the summer. A possible explanation of the winter peak could be the migration into the fishing area of large lobsters coming from deeper waters, probably due to rough weather. This is the period of ground swells of "rebosos," which the fishermen look forward to, since high catches are made after periods of bad weather. The catch per unit of effort increases, and the average lobster is heavier than during previous months. The summer peak could possibly be caused by a higher congregation of lobsters related with breeding activities.

There is an abrupt fall in the production at Culebra during the months of January, February and March. This decline coincides with the period of maneuvers of the U. S. Navy which takes place in those waters, during which time the fishing area is reduced to two or three miles off its southern coast. Even though there is no doubt that this reduction in the fishing area and in the fishing effort is the main causative factor in the considerable drop in the landings, this does not rule out the possibility that some biological factor might also be involved. The general picture presented by this region is that of a typical virgin area which, when subjected to exploitation, is characterized by a high yield, older animals being predominant in the catch. In this case more fishermen were attracted to the fishery, with the subsequent increase in effort producing a still higher yield in the second year. This temporary increase was followed by a sharp decline during which some fishermen started leaving the area due to the decrease in the catch per unit of effort. Finally the fishery seemed to reach a state of

equilibrium in 1955, the fishing pressure remaining more or less constant since then. The decrease in production since 1951, therefore, is probably due to the natural behavior expected in a new fishery, and not caused by depletion. The possibility exists also that this picture might prevail in the other lobster areas of Puerto Rico.

The estimation of fishing effort was determined using as unit the catch per lift per trap. This catch per unit of effort was found to be 3.6 pounds for the wooden trap, and 2.5 pounds for the wire trap. Dawson (1949), in his study of the lobster fishery of Florida, reported the average catch per wooden trap in a string of 100, to be six crawfish. According to this author the lobsters caught by those traps had an average weight of 1¼ pounds, bringing the production per trap to about 7.5 pounds. This catch is approximately 2.1 times the production of our wooden trap and three times that of the wire trap. This catch per unit of effort should be regarded as an indication of availability rather than of abundance, since the lobster population is characterized by a seasonal pattern of movements upon which is superimposed an erratic movement associated with foraging and weather, the animals sometimes moving beyond the range of the fishery.

TABLE 2

CATCH PER UNIT OF EFFORT, 1956-57
(In Pounds of Lobsters)

Month	Wooden Trap	Wire Trap
July	3.0	3.0
August	2.9	3.3
September	1.7	—*
October	2.2	—
November	5.5	—
December	—	6.5
January	5.7	2.3
February	4.4	1.2
March	4.2	0.6
April	2.5	0.9
Average	3.6	2.5

*Figures unobtainable.

The fact that two different traps are used at the Island of Culebra presents an unique and interesting opportunity of establishing a difference in their relative efficiency and selectivity. This difference, besides affecting the estimation of catch per unit of effort and other statistics, can be of economic importance to the fishery. (See Table 2). The comparison of gears was made over a full year. The wooden trap was found to be selective on smaller sizes, and to produce a higher number of lobsters than the wire trap, catching an average of 1.9 lobsters per lift, with an average weight of 1.8 pounds per lobster. The wire trap caught an average of 1.2 lobsters per lift, with an average weight of 2.7 pounds per lobster. According to the data collected, the wooden trap produced a catch valued at an average of $0.89 per lift. The average lobster production of the

wire trap was found to be $0.62 per lift, which added to an average fin fish production of $0.22 per lift, raised its total production to $0.84. Traps are lifted normally every three days, resulting in an average of ten lifts per month, which would bring the total production per month to $8.90 and $8.40 respectively. Deducting from these figures the monthly cost and depreciation, a net income results of $8.40 per wooden trap and $7.15 for the wire trap. This net income is 16.8 times greater than its monthly cost and depreciation in the case of the wooden trap, and only 5.7 times greater in that of the wire trap. Based on these observations of its efficiency, 15 wooden traps have been bought by the Division of Forests, Fishery and Wildlife to be introduced experimentally on the western coast of Puerto Rico at the end of this month.

Biology

The general biology of *Panulirus argus* in Puerto Rico is similar to that described for this species in other areas of its range. It is primarily a scavenger inhabiting areas offering natural protection.

The sex ratio was found to be 50:50, a similar condition to that found by Dawson and Idyll (1951) in Florida; nevertheless, males were predominant in the spearfishermen catches. Sexual maturity seems to be attained when females reach a carapace length of 3.4 inches, or a total length of approximately nine inches.

Females carrying spermatophores and eggs were observed at all months. What could be called the peak of the spawning and mating seasons occurred from April to June, the percentage of worn spermatophores and mature eggs increasing after those months. (Table 3 and Fig. 2).

TABLE 3

SEX RATIO AND BREEDING DATA OF SPINY LOBSTERS FROM CULEBRA, PUERTO RICO
June, 1956 - April, 1957

Month	Males	Females		Females With Eggs		Females With Sperm	
	No.	No.	%	No.	%	No.	%
June	24	37	39	17	46	33	89
July	291	271	48	112	41	243	90
August	451	381	46	149	39	285	75
September	—	—	—	—	—	—	—
October	110	130	54	45	35	78	60
November	69	83	55	28	34	60	72
December	87	79	48	9	11	53	67
January	56	60	52	16	17	31	52
February	42	27	39	13	48	20	74
March	30	27	47	14	52	21	78
April	45	31	41	20	65	21	68
Totals	1,205	1,126					

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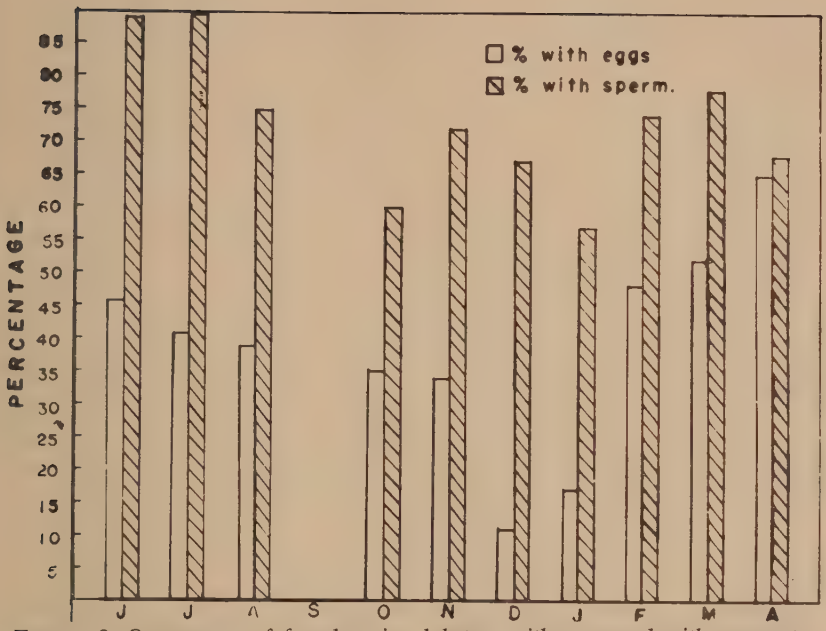

FIGURE 2. Occurrence of female spiny lobsters with eggs and with spermatophore expressed as a percentage of the total number of females from June through April. Culebra, P. R. 1956-57.

The number of eggs laid by the lobster was found to range from 434,000 to 1,691,000, with an estimated average of 933,000 eggs. The number of eggs was found to increase with the size of the animal, although several large specimens were found to have a lower number of eggs than would be expected. This number of eggs calculated for the lobster in Puerto Rico seems to approach the results obtained by Creaser (1950) for the same species in Bermuda.

The average weight of the market lobster in Puerto Rico was found to be two pounds, with an average size of 11 inches of total length. The average weight of the males was 2.3 pounds, while that of the females was 1.7 pounds. Mattox (1952) reported an average length of 12.02 inches, and an average weight of approximately 2.56 pounds (this last figure was calculated using his average weights for males and females). His figures are not only higher than the averages presented above, but they are also higher than our averages of September and October, the months covered in his studies. Nevertheless, he reports the 1.5 pounds size to be the size-group of greatest frequency in the females, and that of 2.25 pounds for that of the males, these size-groups being the same found to be most prominent by the writer. This would suggest that even though there has been a drop in the average size and weight of the lobsters in Puerto Rico, probably due to the elimination of the larger animals, the population composition has remained more or less the same. Figures 3 and 4 illustrate the total length-carapace length and the weight-lengths relationships of the spiny lobster in Puerto Rico.

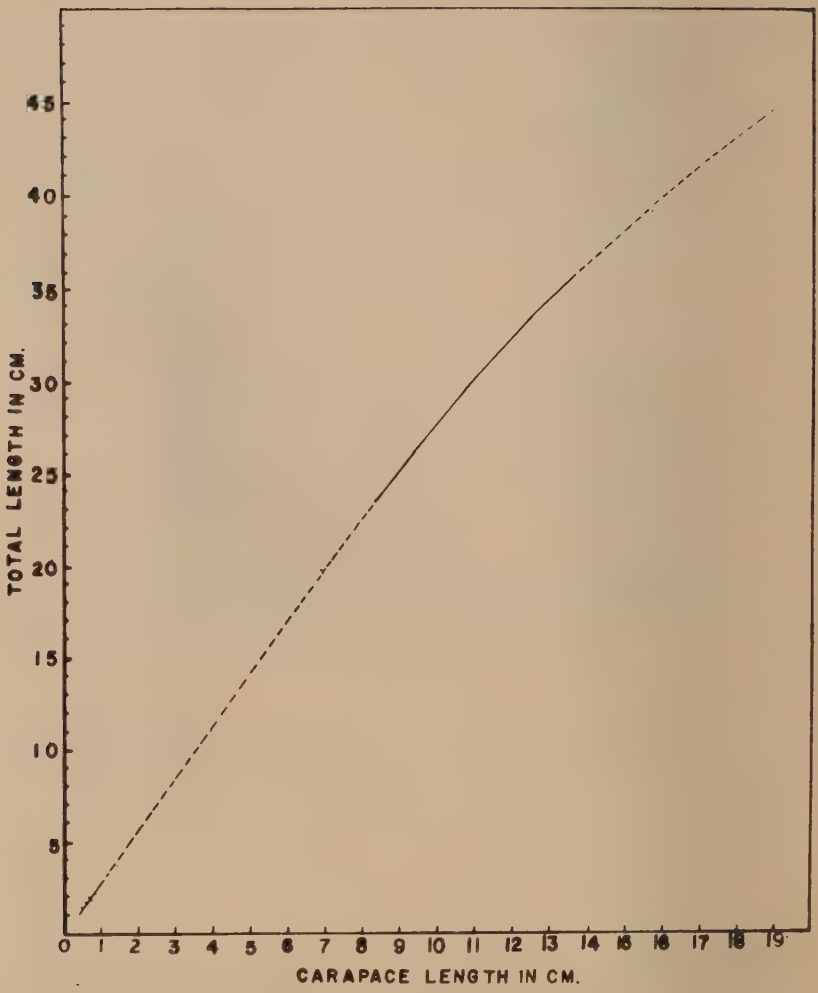

FIGURE 3. Total length—carapace length relationship of the spiny lobster *Panulirus Argus* from Puerto Rico.

Regulations and Other Considerations

The only protective regulation concerning the spiny lobster in Puerto Rico forbids the taking, killing, destruction, possession or selling of berried females during any month of the year. Considering the fact that, as postulated by Smith (1948), in species like the spiny lobster having a high fecundity, the reproductive potential would probably not be endangered by heavy fishing until the fishery itself had become economically unsound, and based on the results of

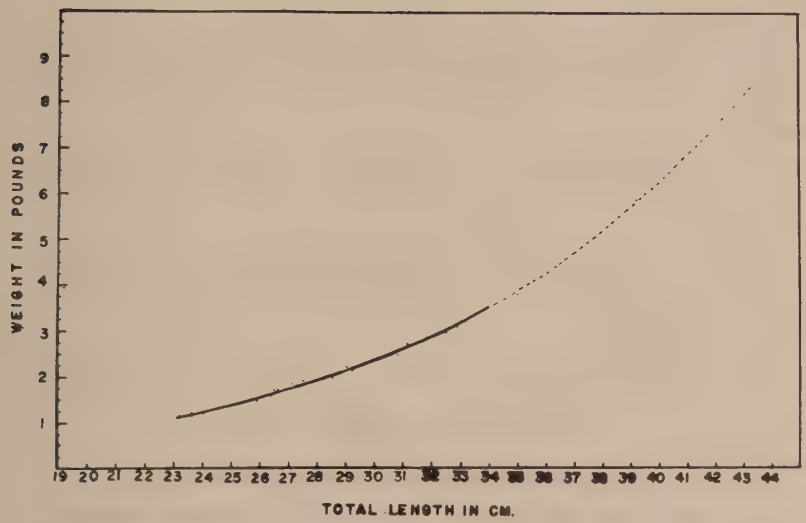

FIGURE 4. Weight-length relationship of the spiny lobster *Panulirus Argus* from Puerto Rico.

this study, it has been recommended that this regulation be abolished. Besides having a doubtful value as a conservation measure, its enforcement curtails the production because of the considerable percentage of berried females present throughout the year. The only regulation which would seem more practical at present would be the establishment of a minimum size-limit similar to that proposed by Dawson and Idyll (1951) for the lobster in Florida, that is nine inches in total length or a carapace length of 3.5 inches. This legal size would prevent the taking of immature females.

The most important step that should be taken in relation to the conservation of this fishery would be the adoption of a statistical system by which accurate measures of catch and fishing effort could be taken.

Further development of this fishery would depend on expansion of the fishing grounds, especially those on the eastern coast, motorization of the fishing fleet, and improvement of the handling and processing methods.

It is probable that we could be dealing with a single population in Puerto Rico, but further investigation would be needed to establish this possibility.

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Historical and Economic Aspects of the Shark Fishery of the Pacific Coast of Mexico

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Fishing is one of man's oldest occupations and science tells us that sharks were known to exist even farther back in geologic time than the Devonian Period of 355,000,000 years ago. It is safe to assume, then, that shark fishing is as old as man. Today a hundred or more different species of sharks populate the oceans along the coasts of every continent. Feared and spurned as a dangerous and predatory inhabitant of the sea, and ignored as worthless in many lands, it is sought as an important source of food and other useful products in other countries.

This paper will recount facts and knowledge obtained from many years in the fisheries of the Pacific Coast of Mexico. The shark fishery had its inception in 1939 and went through a great development which resulted in a full scale fishery in 1950. The writer has been associated with this fishery from the beginning.

The Pacific Coast of Mexico, with its 4,000 miles of coastline, has more than its share of the world's shark population, including many species. People of old civilizations before the Spanish Conquest were not a seafaring folk. Hence the shores were sparsely populated and fishing was limited to a simple activity close to shore that produced sharks of the smaller species, such as the dog fishes, locally known as "Cazon," and still very popular sold fresh. The same may be said of the four centuries of Spanish rule and the Republic later, when small progress in the fisheries in general was recorded.

The only true commercial shark fishery in Mexico, up to the second World War, was centered at La Paz, in the southern half of the Lower California Peninsula, inside the Gulf of California. The first white settlers of this beautiful but inhospitable waste of land, practically isolated by land and sea, were Span-

ish missionaries. Other seafaring nations soon contributed new blood from England, France, Norway and elsewhere, either by shipwreck or desertion from pirate boats or merchantmen that ventured in the newly discovered Pacific in the 17th to 19th centuries. Today, after generations of amalgamation with the Spanish and aborigines, their descendants still bear such names as Winckler and Davis. The shark fishermen of the present are upholding the great sea and fishing traditions of their ancestors. The year-round abundance of fish and shark in those waters, the favorable climate, and isolation from the mainland, forced these people to turn to the sea. Thus they matured into hardy seamen, pearl divers and fishermen, and with the advent of the market for Vitamin A in the second World War, they were to become the backbone of the most important shark fishery in the world.

This same area that gave birth to the new commercial shark fishery is also famous for its fabulous pearl banks, exploited since the 18th century. Some of the finest pearls, in white, black and multihued colors were produced here. One of the most notable was a 75 carat gem of perfect form and orient, found in the year 1882. These shark fishermen were also expert divers and worked seasonally at this activity until the shell banks died in the year 1937. This may be a diversion from the main subject, but it is of interest to mention the untimely end of the rich pearl fishery which has been blamed on Japanese fishermen, who were accused of poisoning the waters because our government refused them a concession of the pearl fishery. It happens, however, that not only were the pearl banks in the Lower California coast affected, but all the populations of the same two species of molluscs found along the coast south to Central America died at the same time. The story is still believed by many, but the real cause has never been scientifically established to my knowledge. The pearl banks have now recovered to some extent, but premature diving soon depletes the resource, with small benefit to anyone.

Returning to the historical aspect, the shark fishery around the La Paz area started commercially when Alfonso Schnabel started buying shark fins and shark liver oil in 1888, and made the first exportation of fins from Mexico to China. The oil was used by tanneries locally. Others followed; Juan Antonio Romero traveled the barren coastline to the north on native burros and mules from Loreto to Santa Rosalfa, to collect the products. Later, at La Paz in 1896, a Frenchman by the name of Gaston J. Vives, provided some competition for the same products, and in 1905 the firm Antonio Ruffo (now "The Perla de la Paz") was established and gave shark products important attention. In 1932 these same merchants began buying dried salted meat for commerce.

With the increasing use and demand for livers rich in vitamin A during the 1930's, the first step in the development of the great shark fishery of Mexico was taken when a man in the fishing and canning business at Guaymas started to collect the fresh shark livers at the Gulf of California islands of Catalina, Santa Cruz and San Jose in the vicinity of La Paz from fishing camps operated primarily for market fish. The first shipment of livers was exported from Guaymas to Los Angeles in June of 1939. However, the first lots were not readily accepted by the California processing plants and the enterprise appeared of doubtful success. The colors, textures and great variety of the Mexican livers were strange to the buyers. The high free fatty acid and high stearine contents were also quite different from those of soupfin shark livers caught by the California boats, and productive of abundant, clear oils of high

potency. The differences were due, in part, to the fact that the Mexican livers come from a warm climate (summer water temperatures of 90° and higher). The livers were held for variable periods under improper conditions, with only the aid of ground salt or other chemical preservatives.

After some hesitation and experimentation, California buyers began to accept these livers at lower prices, and soon afterwards, with the increasing demand under war conditions, the Mexican product was in firm demand.

Notwithstanding the adverse conditions noted, Americans, some interested in buying the livers, and others in fishing for shark, were eager to obtain a foothold on this new resource. Local business men and fishing interests also were quick to realize the possibilities, and promoted buying and fishing activities through the individual canoe fisherman, fishermen's cooperatives and boat owners. By the summer of 1942 the fever had caught hold, and shark livers were the much sought new gold of the sea.

Most prominent of these American enterprisers was Mr. Howard A. Nibecker of the Technical Fisheries Company of San Francisco, whose faith, dedication and encouragement were contributing factors in the phenomenal growth of the new industry. Other firms followed, the most important of which was Van Camp of Terminal Island, California, who established a local company headed by the retired tuna clipper captain Louis Camillo. The California Packing Corporation, The Borden Company, The Atlantic Coast Fisheries and others carried on operations during the boom with some success; others had little success.

Thus, from the original groups of canoe fishermen that started in June of 1939, the shark fishing activity spread rapidly, first at Guaymas, which became the center of the operation for the Northwest, to Puerto Penasco in the north end of the Gulf, and then to the south to every fishing hamlet along the coast, down to Mazatlan.

By the year 1943 one of the largest producers of livers established the first shark liver oil processing plant at Guaymas, equipped with the most modern machinery and laboratory of the time, with the encouragement and technical assistance from the brokerage firm of Consumers Import Company, Inc. of New York City. This was made possible only by the cooperation of the U. S. Government, due to the great difficulties in obtaining the necessary equipment and materials during those difficult first years of the war. First priority was granted the needs of this new industry that was to supply the much needed vitamin A oils to the allied countries in the war effort. This new company was Cia. Vitaminica y de Extracciones, S. A., and was a subsidiary of Pesquera de Topolobampo, S. de R. L., a General Abelardo L. Rodriquez enterprise. General Rodriguez's farsightedness envisioned and promoted the construction of this plant. The new company set up offices and laboratories at Puerto Penasco, La Paz and Mazatlan for the purpose of buying livers on the ground. The laboratory was equipped for determining vitamin values by assay, making possible immediate payment to the fishermen.

Soon after, in August of 1944, Howard A. Nibecker established a new shark liver oil vitamin A concentrating plant at Guadalajara, Jalisco, which contributed to the development of new fishing areas from Mazatlan south to San Blas, Puerto Vallarta, Manzanillo, Zihuatanejo, Puerto Angel and Acapulco, Salina Cruz and Tonala, close to the Guatemalan border. Thus, the whole length of the Pacific Coast was actively fishing for shark. The operation of this

plant was successful until August of 1949 when fishing was practically suspended because of the break in price of vitamin A.

With increasing demand for vitamin A oils, prices maintained high levels throughout the war and post war years, until the great fishing fleets of Japan, Norway, England, Iceland, Canada and many others were reorgnized and returned to normal production. Catches of shark and pollock in Japan and of cod and whale in the other countries started the break in vitamin prices in 1947. At the same time, unfortunately for the fishing industry, several pharmaceutical laboratories were developing a synthetic vitamin A. This began to be produced in large quantities and at low costs, and soon provoked new reduction in the prices of fish oils. By 1950 competition was so keen between the natural vitamin A from fish liver oils and the synthetic product that the price structure collapsed to present low levels, never to recover.

This market situation, together with a change of standards in vitamin A values introduced in the U. S. Pharmacopea, (by which, for all practical purposes, the potency values were reduced by approximately 25 per cent as compared to the previous accepted methods and values) caused the virtual collapse of the ten year old industry.

Some shark fishing is still done, and it is worth-while to describe the methods employed. The individual fishermen have used dugout hardwood one piece canoes from time immemorial, and still prefer them to other types and materials. They are strong, seaworthy and last twenty or more years. However, when the shark boom developed, a quickly constructed light skiff made of pine lumber was pressed into service and some of them are still fishing today. The canoe has a light high mast for a sail and they go out to sea 10 to 20 miles every day. They rely on a good pair of oars and a paddle for motive power. Along the mainland these canoes also operate in bay shrimp fishing during the season from August to February, which fits very conveniently with the best shark runs from March to June, when tropical storms make it impossible to fish for shark in open waters in such small craft. At present about 90 per cent of the canoes are powered by outboard motors of from five to 25 h.p. and the most arduous part of fishing has been eliminated. Small boats, of from 18 to 35 feet in length, powered by gasoline and diesel engines were constructed by the hundreds.

Both canoe and boat fishing is done with set lines and set nets, at depths from 10 to 100 fathoms. The nets used are from 14 to 18 inch mesh, of 72, 84 and 96 cotton threads, between 100 and 150 fathoms long. The first shark fishing, however, was done with more rudimentary gear, such as harpoons thrown by hand from the canoes when the sharks come to the surface to bask. These are still being used, especially for the spring hammerhead run, when the shark are found on the surface during the day. The water must be calm with no breeze ruffling the surface, so that the sharks can be spotted and struck before being disturbed. It is uncanny the way these fishermen place the harpoon on the target every time from a distance of 30 to 60 feet. The shark is brought to the side of the canoe, which is quite a feat, with the shark and harpoon twirling crazily in the water until the animal is tired and is finally killed. Only the liver and the fins are taken. The meat of this shark is dark and tough and has no demand, and the hide is thin and sours easily, and is damaged in the struggle. The harpoon, which is a 12 foot, round steel rod one half inch in diameter, is a coiled mass of steel at the end of the struggle and the fisherman

must immediately straighten it before it can be used again. This is strenuous work, but is well repaid when the run and weather are good, since the hammerhead is usually the richest in vitamin potency.

The hammerhead sharks are commonly known as "Cornuda." There are four species, one that is of small size and has the local name of "Chicotera." The other common species are brown and dark blue in color, the fourth kind is a large species called "Arqueada," the name being derived from the long curved dorsal fin. There are other sharks valuable for their vitamin potency, such as the Blacktip, which we call "Volador," "Isala" or "Sardinero" depending on the locality, and the "Gambuzo," the "Ingerto," "Prieto," "Chato" and others. The scientific names of these sharks are omitted because of the chance of error. Most of these species are not found in the U. S. waters and only incomplete investigations have been made of the sharks on this coast by biologists. There are ten or more other species producing less valuable livers. Some have practically no vitamin potency, but they have better quality meat, hides and fins than the species mentioned above.

Dried, salted shark meat was first sold in commerce at La Paz in 1932 for the domestic market and labelled "domestic cod." The Mexican people inherited from the Spanish a liking for dried cod imported from Spain and Sweden. Therefore, a ready market was available, especially in certain seasons and religious holidays. It is the lowest price animal protein available to the people today. In recent years the handling and preservation has been improved considerable and more recently it is being put up in attractive individual polyethylene bags.

The dried fins, well trimmed and sun dried, have been shipped mostly to San Francisco since the last century, a few going directly to China. The market for fins has been closely related to the history of China and has suffered violent fluctuations throughout the years. All fins went to China for cleaning, because of cheap labor, and were mostly consumed there, except for an important volume reshipped to San Francisco for use by the Asiatic population of California. Since the suspension of commerce with Red China, Chinamen in San Francisco have developed facilities for cleaning the fins there and only the surplus of fins are sent to Hong Kong, now the distributing center for this product in the Orient.

The hides are a relatively new product. Ocean Leather Corporation of Newark, New Jersey were the originators of the tanning process and have made a most durable and beautiful grained leather since 1925. Credit should be given to this firm for developing shark fishing in many lands. In our Pacific Coast of Mexico they provided the know-how and equipment to produce good hides even before the shark fishing boom started, back in the year of 1937. During the war years there was little demand for these hides, but demand has returned in the last two years and Mexico is again producing shark hides for this firm, the only buyer. Mexican firms have made several attempts at processing these hides, as have some California firms, but without success.

It is interesting to note that the development of the shark fishery took place at the same time as that of the shrimp high seas fishery. The economic contributions of the shark industry, as well as the experience in fishing and in boat building, made possible the great development of the shrimp industry of today. In those years the shrimp fishermen awaited with anxiety the end of their shrimp season to start the shark fishing that lasted during the summer.

In many a year shark was the salvation of fishermen after a bad shrimp season.

In closing, some remarks on the present situation are in order. It has been pointed out that commercial shark fishing in Mexico almost died in 1950. Not completely, however. The same old stalwarts that gave birth to the industry in the Lower California Peninsula are still fishing for shark. They must do so if they are to obtain a living, and fortunately, conditions are now improving. These fishermen are learning to produce more products, such as livers for pharmaceutical and animal foods, dried salted meat for human consumption, dried fins for the export market and hides for fine leathers. Soon methods will be found to produce fish meal. All of these products will increase the profits of the fishermen. Mexico's population is increasing by over a million a year, and so is the standard of living, and the demand for these products will improve prices correspondingly. At present the fisherman gets a low return for the products commensurate with the efforts involved, because shark fishing is not easy and the production per man is low. Better fishing methods and equipment must evolve to make the overall operation more profitable.

With the reopening of the shark liver processing plant at Guaymas, the fishermen can obtain higher prices for shark livers and new impetus is being given to shark fishing all along the coast. This new enterprise has been given the fullest cooperation of the government by exemptions and reductions in taxes, (fishing, income, export and other taxes) and a new era may be in the offing for this once important industry.

DISCUSSION

Caribbean and General Session

Discussion Leader: William Herrington

Discussion Panel: Ralph Camacho, Jose A. Suarez, Richard Robins, Charles Emmert, Louis Bonnet, Philip Van Gelderen

Marine Fisheries Versus Fish Culture for the Caribbean: An Outsider's Point of View

John E. Bardach

Q. Camacho: Is it likely that fish culture will replace marine fisheries in the Caribbean countries?

A. Bardach: This is unlikely. Instead, I expect culture will simply continue to supplement marine catches. The problem involves availability of suitable land for the construction of ponds. The agricultural economy of the area is characterized by one or two crops, and the lands are owned by a few large landowners, thus preventing adequate distribution among the local people. The governments must, of necessity, maintain patronage over the fish culture program for some time to come to provide capital, land, breeding stocks and to manage the operation.

Q. Robins: Bilharzia is a serious parasite problem in Puerto Rico. Is it possible that fish culture will make available more habitat for the parasite and thus add to the problem?

A. Bardach: The native host snails, *Autralorlus glaburatus,* are stream dwellers that may not affect pond fishes and humans directly.

Bennett: (Comment) The snails are found in both running and still waters, but some work has been done to control the snails.

Q. Emmert: What species of fish have proved best for pond culture in the area?

A. Bardach: So far a carp and Tilapia have been used. The carp brings a better price and grows larger; Tilapia is more prolific and grows faster.

Q. Viosca: Have you tried more than one species of Tilapia?

A. Bardach: Only *T. mossambica* has been used to my knowledge.

Q. Viosca: Have the black bass been introduced in many locations?

A. Bonnet: In 1930 Dr. Hildebrand made a study of the fresh water conditions of the Puerto Rico area. He found no local species of economic importance and he recommended the introduction of bluegills, catfish and large mouth bass. Hatcheries were established and the fish did well. Fresh water fish represents one third of the total fish production and is a low priced source of protein for Puerto Rico. We have used black bass also with great success as a food species. Annual production is about 600,000 pounds. The species does not compete with the other local fish to any great extent. The fear that mosquito eating fish would be wiped out was unfounded and malaria is practically nonexistent at present.

Q. Emmert: What is the total protein from fish available to Jamaican people?

A. Bardach: About 15,000,000 pounds from marine fishing, about 30,000,000 pounds of imported fish, mostly cod, and a much smaller amount from pond culture, for about one million people.

Q. Emmert: Have these countries cultured any shellfish?

A. Bardach: No shellfish culture is practiced on a commercial scale, but there are plans in this direction. For example, in Curacao Dr. Zaneveld of the Marine Biological Station, has looked into this possibility of shellfish culture in bays and around islands which are well protected.

Q. Van Gelderen: Is there money for development and exploration of the fish resources out to 100 fathom depth?

A. Bardach: No. The investment of capital will not be attractive to foreign investors because of the diversity of the operation and the governments have not enough capital to support this type of research.

Weather and Fisheries in the Caribbean

Richard T. Whiteleather and James B. Higman

Q. Camacho: You showed a relationship between wind strength and the roughness of the sea. Do not currents and tides have something to do with roughness?

A. Whiteleather: When the currents are opposed to the winds this can result in extremely rough seas. Fortunately, there are few such areas in the Caribbean and the fishermen can handle the small vessels with relatively little trouble there.

Q. Emmert: How many days a year can you fish in the Caribbean area?

A. Whiteleather: It depends very much on the type of boat used. A 40-80 foot vessel would probably fish about 50 per cent of the time.

Emmert: (Comment) In the western Caribbean fishing is restricted not only because of the size of the boats, but also because of the lack of adequate weather stations and reliable forecasts.

Bardach: (Comment) The average Bermuda fisherman does not fish more than 150 days per year. The visibility of the buoys is the limiting factor.

Q. Strasburger: You said the increased catches shown to be made in rough weather in the longline fisheries may be due to bait movement. How can this be true at greater depths if the winds only move the surface waters?

A. Whiteleather: Movements of the longlines agitate the droplines upon which the baits are hooked.

Herrington: (Comment) Also the gear may be less obvious to the fish on a rough day because of increased turbidity of the water.

Iversen: (Comment) In Tortugas shrimp fishermen tell us that the catches of shrimp go up after storms. Also, the pink shrimp, normally caught at night, can be fished during the day following heavy storms, perhaps because the turbidity of the water cuts the light below the normal level.

The Lobster Fishery of Puerto Rico

Carmelo Feliciano

Q. Robins: The size limit regulation is stated to be based on that in Florida. Do we know enough about the young stages to justify such a regulation? In view of the evidence that a given local population of spiny lobsters may depend on recruitment of larvae from another area "down current," are we helping the local fishery or the fishery further up the coast by a size limit regulation? Perhaps the control is needed in the Virgin Islands rather than Puerto Rico?

A. Idyll: The purpose of the size regulation is not to protect the spawners on the assumption that the size of the spawning

population may be dangerously reduced. The regulation is designed to help the industry get the maximum weight and value of the harvest.

Q. Viosca: What is the possibility of developing a soft shell lobster industry?

A. Emmert: In British Honduras we have packed and shipped to California about 3,000 pounds of soft shell lobsters, but we do not know how the public will accept them. Preparation of soft shell lobsters is different from that of regular lobsters.

The Shark Industry of Guaymas, Mexico

HECTOR FERREIRA

Q. Suarez: Do you use longline gear to catch sharks in Mexico?

A. Ferreira: No.

Q. Herrington: Does there seem to be any possibility for increased use of shark meat?

A. Ferreira: Yes. The light meat is being marketed to some extent now, but there is a lot of waste in dark meat and in inedible species. We are working on methods of producing fish meal on a small scale. The problem of transportation is still a serious one, thus, small plants seem to be the best approach.

Q. Whiteleather: Is there any possibility of using the same boats in both the shrimp and shark fisheries?

A. Ferreira: There could be some interchanging but at the present time the shrimp fishing is good, so there is no reason for them to go shark fishing.

Q. Whiteleather: Is there any possibility of importing sharks into Mexico from other Caribbean areas?

A. Ferreira: No, because of the high import tariff.

Q. Saenz: Is shark meat sold in Mexico under its true name?

A. Ferreira: In most cases there is no specific name given to the product; it is just called "dry fish." In some cases it is labelled as shark meat.

Q. Strasburger: What uses are there for shark skin?

A. Ferreira: The hide produces a fine leather that is very much in demand for certain quality items such as brief cases, billfolds, belts, shoes, etc.

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A & B Fish Co.
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St. George Packing Co.
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Ferlisi, Fred A.
Marine Supply and Oil Co.
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